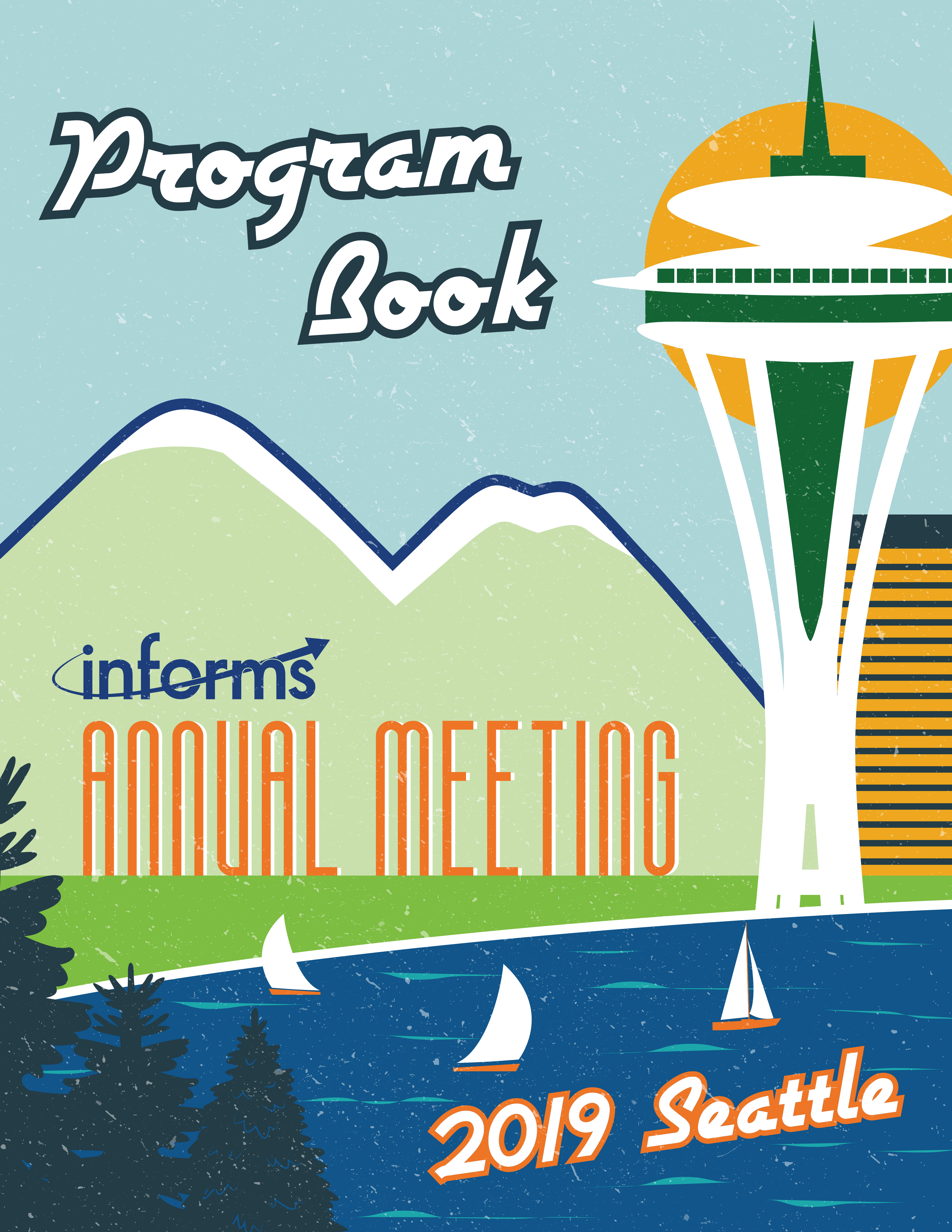
Program
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ANNUAL MEETING
2019 Seattle

How to Navigate the Technical Sessions

There are four primary resources to help you understand and navigate the Technical Sessions:

- This Technical Session listing, which provides the most detailed information. The listing is presented chronologically by day/time, showing each session and the papers/abstracts/authors within each session.

The Session Codes

SA01

Room number. Room locations are also indicated in the listing for each session.

Time Block. Matches the time blocks shown in the Program Schedule.

The day of the week

Time Blocks

Sunday - Monday

8:00am - 9:30am

9:50am - 10:50am

11:00am – 12:30pm

1:30pm – 3:00pm

3:10pm - 4:00pm

4:30pm – 6:00pm

Tuesday

7:30am - 9:00am

9:30am - 10:20am

10:30am - 12:00pm

12:05pm - 1:35pm

2:00pm - 3:30pm

3:40pm - 4:30pm

4:35pm – 6:05pm

Wednesday

8:00am - 9:30am

10:00am - 10:50am

11:00am - 12:30pm

3:20pm - 4:50pm

Rooms and Locations /Tracks

All tracks / technical sessions will be held in the Washington State Convention Center

Sunday, 8:00AM - 9:30AM

■ SA01

CC- Room 201

Data Mining Best Student Paper

Sponsored: Data Mining

Sponsored Session

Chair: Ali Dag, Vermillion, SD, 57069, United States

Co-Chair: Evangelos Triantaphyllou, Louisiana State University, Division of Computer Science & Engineering, Baton Rouge, LA, 70803, United States

Co-Chair: Changqing Cheng, Binghamton University, Systems Science Industrial Engineering, Binghamton, NY, 13902, United States

1 - The Price of Interpretability: Optimal Explanations of Linear Models

Arthur J. Delarue, MIT, Cambridge, MA, 02139, United States, Dimitris Bertsimas, Patrick Jaillet, Sebastien Martin

The ability to explain a predictive model's reasoning to a decision-maker can increase trust and expose biases. However, attempts at interpreting models are often ad hoc, and interpretability is not a well-defined concept. We propose a general optimization framework to create explanations for any linear model, by decomposing it into a sequence of models of increasing complexity using coefficient coordinate updates. From this decomposition, we can derive a family of interpretability metrics generalizing typical proxies and study the tradeoff between interpretability and predictive accuracy.

2 - A Hierarchical Expected Improvement Method for Effective Bayesian Optimization

Zhehui Chen, Georgia Institute of Technology, Atlanta, GA, United States, Simon Mark, C.F. Jeff Wu

Expected improvement (EI) is a popular Bayesian optimization (BO) method, due to its closed-form acquisition function. However, EI is so greedy that it may stuck at suboptimal points. To address this, we propose a new hierarchical EI (HEI) framework. HEI preserves closed-form and corrects the over-greediness of EI. Under certain prior specifications and smoothness assumptions, we establish the rate of global convergence for HEI. We then introduce several hyperparameter estimation methods, which allow HEI to mimic a fully BO procedure while avoiding expensive Markov-chain Monte Carlo sampling. Numerical experiments show the improvement of HEI over existing BO methods.

3 - Optimal Hierarchical Clustering on a Graph

Gokce Kahvecioglu, Northwestern University, Evanston, IL, 60208, United States, David Morton

Given an undirected graph with positive weights on the edges we study a parametric bi-objective graph clustering problem. We remove a subset of edges to break the graph into smaller pieces, i.e., connected components, or clusters. We seek to maximize the number of clusters while minimizing the weight of the removed edges. We identify nested solutions that lie on the concave envelope of the efficient frontier, yielding a hierarchical family of clusters, in strongly polynomial time. We demonstrate the performance of our approach on a network defined by the schedule of football teams in the National Collegiate Athletic Association, and on a set of synthetic networks.

4 - A Spatiotemporal Prediction Approach for a 3D Thermal Field from Sensor Networks

Di Wang, Peking University, Beijing, 100871, China, Xi Zhang, Kaibo Liu

Please check the mobile app or online for this abstract.

■ SA02

CC- Room 202

Data-driven Decision Making

Sponsored: Data Mining

Sponsored Session

Chair: Mengqi Hu

1 - Energy-aware Task Planning for Solar-Powered Robot via Deep Reinforcement Learning

Di Wang, University of Illinois at Chicago, Chicago, IL, 60607, United States, dwang66@uic.edu, Mengqi Hu

To improve the operational life of robots, it is critical to combine task planning and energy schedule. In this paper, a novel data-driven decision approach based on deep reinforcement learning with a link information filter is proposed to ensure that robot can maximally harvest solar energy by considering time variance in solar irradiance. Our simulation results demonstrate that the data-driven approach can outperform existing heuristic optimizers.

2 - Online Model Adaptation for Building Energy Consumption Real-time Prediction

Jinghang Li, UIC, Chicago, IL, United States, jli238@uic.edu, Mengqi Hu

Building energy consumption prediction plays a critical role in achieving a sustainable smart building. Most of the existing data-driven predictive models are trained using historical data and fixed during the execution stage which cannot adapt well to real-time data. In this research, we develop a meta-learning-based approach to adaptively improve the pre-trained predictive model through efficiently digesting real-time data. Our simulation results demonstrate that the adaptive predictive model can efficiently capture the dynamics in real-time data and perform better than static models.

3 - Learning to Predict Real-time Electricity Price Based on Trusting Features

Rui Dai, University of South Florida, Tampa, FL, 33613, United States, Hadi Charkhgard

Real-time pricing in energy market is adopted by the utility companies as one of effective means for their demaSB44nd response programs. The end users of real-time pricing plan can create price arbitrage and adjust their electricity usages to reduce their costs, if they can predict the real-time price accurately. In order to capture a better prediction of real-time price, we propose a learning technique to predict the real-time price based on the weather data and trusting features. The trusting features is generated by operational results of the users participating the real-time pricing program. Computational study shows the effectiveness of our predicting technique.

4 - Spatial-temporal Wind Power Probabilistic Forecast with Quantile Regression

Zhi Zhou, Argonne National Laboratory, Argonne, IL, 60439, United States, zzhou@anl.gov, Bo Wang, Wei Xie

To support both planning and operational decisions for seamlessly integrating high penetration of wind energy into the power grids, in this paper, we introduce a nonparametric spatial-temporal wind power probabilistic forecast. Specifically, at any time and location, the wind power generation uncertainty is characterized by a sequence of quantiles. We develop a Gaussian process based metamodel to simultaneously model a sequence of quantiles with the spatial and temporal dependence. It can be used for both long-term and short-term wind power probabilistic forecast.

5 - Deep Learning Based Automatic Fault Detection and Diagnostics for a Multi-zone Office Building

Yang Chen, Oak Ridge National Laboratory, Oak Ridge, TN, 37830, United States, Miao He, Yiran Yang, Xiaochun Feng

Along the thriving of learning based artificial intelligence for decision making, automatic fault detection and diagnosis (AFDD) becomes more accurate and efficient with big data availability. In this study, a deep learning based AFDD framework is developed for a large office building focusing on air-handling units and rooftop units, where the adaptive learning method is explored to tackle the challenge of domain transferring. The proposed approach is validated and compared with several promising learning algorithms on a public accessible testing data set.

■ SA03

CC- Room 203

Fairness in Machine Learning

Sponsored: Data Mining

Sponsored Session

Chair: Himabindu Himabindu

Co-Chair: Berk Ustun

Presenter

Elisa Celis, Yale University, New Haven, CT, United States

1 - Debunking the Myth of the Fairness Versus Accuracy Trade-off

Joshua Loftus, Assistant Professor, New York University, New York City, NY, United States

Fairness in machine learning and AI is often posed as a trade-off between satisfying fairness constraints and achieving greater prediction accuracy. From a purely optimization perspective this seems reasonable, but fairness is a property concerning the real world and not just the model and its predictions. A causal modeling approach to fairness helps to make this explicit and allows us to highlight several reasons why the trade-off framing may be misleading. With causal models we can understand how sample selection bias, heterogeneous treatment effects, and interference can lead to situations where imposing fairness constraints results in a greater global optimum.

2 - Does Mitigating MI'S Impact Disparity Require Treatment Disparity?

Zachary Lipton, Carnegie Mellon University, Pittsburgh, PA, United States

ML algorithms are increasingly operationalized in real-world decision-making. Unfortunately, real-world tasks rarely fit the ML contract. Training data is seldom representative, and targets are often weak surrogates for real desiderata. While practical ML ignores interventions, predictions typically drive decisions. Questions concerning AI ethics necessarily concern the processes generating our data and the impacts of automated decisions, but proposed solutions fail to tackle these problems. This talk illustrates the shortcomings of proposed solutions for mitigating societal harms and contemplates when (today's) ML systems should be off the table altogether.

3 - A Critical Review of Fair Machine Learning

Sharad Goel, Stanford University, Huang Engineering Center, Stanford, CA, 94305-4121, United States, scgoel@stanford.edu

The nascent field of fair machine learning aims to ensure that decisions guided by algorithms are equitable, and over the last several years, several formal definitions of fairness have gained prominence. In this talk, I'll argue that these fairness definitions generally suffer from significant statistical limitations, and, perversely, can harm the very groups they were designed to protect. By highlighting these challenges in the foundation of fair machine learning, I hope to help researchers and practitioners productively advance the area.

■ SA04

CC- Room 204

Sequential Decision Making in Healthcare

Sponsored: Data Mining

Sponsored Session

Chair: Nick Street

1 - Personalized Heartsteps: A Reinforcement Learning Algorithm for Optimizing Physical Activity

Peng Liao, Harvard University, Cambridge, MA, United States, Kristjan Greenewald, Predrag Klasnja, Susan A. Murphy

With the recent evolution of mobile technologies, mobile devices can be used to provide treatment whenever needed and adapted to the user. Just-in-time Adaptive Interventions (JITAIs) are composed of decision rules that map user's context to a treatment, delivered via the mobile device in real-time. In this work, we develop a Reinforcement Learning (RL) algorithm that learns and improves the decision rules for JITAIs as the data is being collected from the user. This work is motivated by our collaboration on designing the RL algorithm in HeartSteps, a physical activity mobile health study, where the RL algorithm will be used to decide whether to deliver a context-tailored activity suggestion.

2 - Optimal Warfarin Dosing Using Reinforcement Learning

Sadjad Anzabi Zadeh, University of Iowa, Iowa City, IA, United States, sadjadanzabizadeh@uiowa.edu, Nick Street, Barrett Thomas

We explore solutions to optimal warfarin dosing, a sequential decision-making problem. The dose-response interaction for simulated patients is extracted from a PK/PD model that incorporates patient information, including age and CYP2C9 and VKORC1G enzymes. The objective to maximize patients' expected health indicator in a 90-day period is optimized using reinforcement learning. The resulting policies are then aggregated to provide easy-to-use protocols for practitioners.

3 - Dynamic Individualized Alarm Setting in the Intensive Care Unit

Steven Shechter, University of British Columbia, 2053 Main Mall, Vancouver, BC, V6T 1Z2, Canada, steven.shechter@sauder.ubc.ca, Hossein Piri, Tim Huh, Darren Hudson

ICUs are rife with alarms, many of which are false. This leads to "alarm fatigue" in which ICU clinicians may inadvertently ignore alarms. We develop a model to dynamically set alarm thresholds for patient's vital signs, as to balance the risks of false positives and negatives. We consider patient heterogeneity in safety limits for vital signs, which are initially only known through a population-based prior distribution. The model performs Bayesian updates during a patient's ICU stay. We also incorporate the "cry wolf" effect by reducing alarm response probabilities with increasing prior false alarms. We present structural properties and comparative statics of the optimal solution.

4 - Optimal Intervention Policies for TJR Postoperative Care Process

Hyo Kyung Lee, University of Pittsburgh, Pittsburgh, PA, 53703, United States, hlee555@wisc.edu, Jingshan Li, Christine Baker, Philip Bain

Successful outcomes of TJR depend not only on the surgery but also on the patients' postsurgical behaviors. To prevent complications or readmissions, patients go through postoperative intervention process in which they receive physical therapy and/or some form of rehabilitative services. While the costs of providing such interventions and readmission penalties are substantial, no methods exist that enable healthcare professionals to determine the optimal timing and target group of interventions. We formulate the post discharge intervention process as a finite-horizon discrete-time Markov decision process and inform the development of evidence-based practice guidelines.

■ SA05

CC- Room 205

Data Analytics and Machine Learning in Healthcare Informatics

Sponsored: Data Mining

Sponsored Session

Chair: Shouyi Wang

1 - Sensitivity Analysis of Tumor Cluster Radiomics to Predict Regional Response on Early-treatment FDG-PET/CT Imaging

Chunyan Duan, Tongji University, Shanghai, 200092, China, duanchunyan77@163.com, Wanpracha Art Chaovalitwongse, Kin Ming Puk, Phawis Thammasorn, Shouyi Wang, Daniel S. Hippe, Larry A. Pierce, Xiao Liu, Jianxin You, Robert S. Miyaoka, Hubert J. Vesselle, Paul E. Kinahan, Ramesh Rengan, Jing Zeng, Stephen R. Bowen

Defining tumor sub-regions on FDG PET for prediction of spatially variant response to radiation therapy can support oncologic management decisions. We conducted a sensitivity analysis of radiomics prediction algorithms (MLR, SVR, logistic, SVM) and tumor clustering algorithms (k-means, hierarchical) on early-RT FDG-PET/CT response prediction errors in lung cancer patients. Prediction performance was more sensitive to tumor region definition than machine learning algorithm.

2 - New Measurement of Information and its Potential Application to Healthcare

Maryam Moghimi, University of Texas at Arlington, Arlington, TX, United States, Herbert W. Corley

We propose a new metric of the information contained in a data set about some specified parameter as a measure of evidence for supporting a hypothesis or comparing alternate hypotheses about the underlying phenomena. Potential applications in healthcare are discussed.

3 - Estimation of Brain Source Activation with Hierarchical Graph Prior

Feng Liu, Harvard Medical School, Boston, MA, 02148, United States, fliu0@mgh.harvard.edu

To infer brain source activation patterns is an integral step to understand how our brain works. Traditional EEG/MEG Source Imaging (ESI) methods usually assume unrelated source activation patterns across different time points or very similar activation patterns across the whole studied period. In this research, we present a probabilistic ESI model based on hierarchical graph priors which renders the flexibility of maintaining consistency as well as allowing distinct activation patterns in the studied period. Comprehensive numerical studies using synthetic data from a real brain model as well as the application to the real data demonstrated the effectiveness of our proposed algorithm.

4 - Deep Representation Learning of Heterogeneous Patient Data for Treatment Response Prediction in Radiotherapy

Shouyi Wang, The University of Texas at Arlington, Arlington, TX, 76019, United States, shouyiw@uta.edu, Jie Han, Art Chaovalitwongse, Stephen Bowen

Learning and data fusion of massive patient data for effective decision making and treatment management is still a challenging problem in current precision medicine research. We present an unsupervised deep representation learning approach to perform data fusion and learn informative representations automatically from massive heterogeneous patient imaging and clinical data. Based on deep representation learning, a predictive treatment response model was developed for patients with lung cancer in radiotherapy. The developed deep representation learning based method is effective for heterogeneous data fusion and predictive modeling with broad applications in medical data analysis.

■ SA06

CC- Room 209

Data Mining in Complex Manufacturing

Sponsored: Data Mining

Sponsored Session

Chair: Byunghoon Kim

Co-Chair: Behnam Tavakkol

1 - A New Uncertain Data Classification Method and its Application in Semiconductor Manufacturing

Byunghoon Kim, Hanyang University, Ansan, 426-791, Korea, Republic of, byungkim@hanyang.ac.kr, Youngseon Jeong, Seung Hoon Tong, Myong Kee Jeong

Classification of defect chip patterns is an important task in semiconductor processing. Several learning algorithms have been developed to classify defect patterns on wafer maps. However, most of them focused on a single wafer bin map. We propose a novel approach to classify distinct defect patterns on multiple wafer maps. To this end, we propose a new uncertain data classification model. In addition, we propose an approach to extract uncertain features that describe the defect patterns on multiple wafer maps.

2 - Semiconductor Wafer Allocation Based on Reinforcement Learning

Minyoung Park, Myongji University, Yongin-si, Korea, Republic of, mypark@mju.ac.kr, Seungyeon lee, Dohyun (Norman) Kim

There are multiple stages in the semiconductor manufacturing process and the production line is more complex than a typical production line. Therefore, the quality of a semiconductor wafer depends on the equipment to which it is assigned. Therefore, assigning wafers to the right equipment is an important issue to maintain quality and productivity. To solve this problem, a new algorithm based on in-depth learning has been proposed.

3 - Deep Learning Based Feature Extraction with Fusion Regularization on Sensor Signals of Semiconductor Manufacturing Process

Jeongsub Choi, Rutgers University, Piscataway, NJ, United States, Jihoon Kang, Myong Kee Jeong, Heejung Lee

Feature extraction is an essential task to build an accurate predictive model for virtual metrology based on raw sensor signals on process equipment in semiconductor manufacturing. Autoencoder is an unsupervised feature extraction method that encodes input data in lower dimensional space. In this talk, we present a new virtual metrology method using the features extracted from deep autoencoder with the regularization on process signals. The experimental result from a case study shows that the proposed method improves the performance of predictive models for virtual metrology.

4 - Quality Degradation Index (QDI): A Novel Cluster-based Quality Index to Monitor Progressive Defects of Wafer

Ghil Ji-ho, Samsung Electronics, Hwaseong-si, Korea, Republic of

As a solution for the difficulties of early warning and inaccuracy in the monitoring of progressive defects in semiconductor manufacturing, a new cluster based Quality Degradation Index (QDI) is suggested. Hierarchical cluster analysis of machine learning technique is applied to merge progressive defect related test items in the wafer map. Through a case study and its simulation experiments we demonstrate how a quantitative quality measure can be obtained by the QDI. Experimental result has shown practical viability to efficiently detect possible progressive defects to improve the production yield effectively as well as enhance the outgoing products quality.

5 - Density-Based Index for Clustering Uncertain Data Objects
Behnam Tavakkol, Stockton University, Secaucus, NJ, 07094, United States, btavakkol66@gmail.com

Uncertain data problems are the type of data mining problems in which data objects are represented by either multiple points or probability distributions. For uncertain data objects, to the best of our knowledge, there are only two developed clustering validity indices in the literature. Clustering validity indices are numerical measures that are used to determine the quality of formed clusters or the optimal number of clusters. In this work, we propose a density-based clustering validity index for uncertain data objects.

■ SA07

CC- Room 210

Modeling and Optimization Methods for Machine Learning

Sponsored: Data Mining

Sponsored Session

Chair: Kristin Bennett

Co-Chair: Yangyang Xu

1 - Cadre Modeling: Simultaneously Discovering Subpopulations and Predictive Models
Kristin Bennett, Rensselaer Polytechnic Institute, Math Sciences Department, Troy, NY, 12180, United States, bennek@rpi.edu, Alex New

Cadre methods are a new class of explainable machine learning models. These methods simultaneously learn subpopulations called cadres as well as linear predictive models for each cadre. Unlike statistical cohorts, these subpopulations are not known a priori; thus, we refer to them as cadres. Since both the cadres and their associated models are interpretable, cadre modeling leads to insights about the subpopulations and the features predictive of the response for each cadre. We present cadre methods for regression, classification, and survival problems. We demonstrate how cadre methods lead to actionable insights via case studies in health care and in the data science job market.

2 - Stochastic Optimization for AUC Maximization in Machine Learning
Yiming Ying, PhD, SUN Y. Albany, Albany, NY, United States, yying@albany.edu

In this talk, I will present our recent work on developing novel SGD-type algorithms for AUC maximization. Our new algorithms can allow general loss functions and penalty terms which are achieved through the innovative interactions between machine learning and applied mathematics. Compared with the previous literature which requires high storage and per-iteration costs, our algorithms have both space and per-iteration costs of one datum while achieving optimal convergence rates.

3 - A Feasible Level Set Method for Stochastic Convex Optimization with Expectation Constraints
Negar Soheili, University of Illinois at Chicago, Chicago, IL, United States, nazad@uic.edu, Qihang Lin, Selvaprabu Nadarajah, Tianbao Yang

Stochastic optimization problems with expectation constraints (SOEC) arise in different applications. Only recently has an efficient stochastic subgradient method been developed for solving a SOEC defined by an objective and a single inequality constraint, where both are defined by expectations of stochastic convex functions. We develop a level-set method to compute near-optimal solutions to a generalization of this SOEC containing multiple inequality constraints, each involving an expectation of a stochastic convex function. We establish convergence guarantees for this method.

4 - Adaptive Primal-dual Stochastic Gradient Method
Yangyang Xu, Rensselaer Polytechnic Institute, Department of Mathematical Sciences, Troy, NY, 12118, United States, xuy21@rpi.edu

Several adaptive stochastic gradients have been designed to solve machine learning problems. They usually decrease the objective error significantly faster than well-tuned standard stochastic gradient method. In this talk, I will present a primal-dual adaptive stochastic gradient method for functional constrained problems and more general saddle-point problems. Convergence and numerical results will be shown.

5 - Mixed Integer Programming and Heuristics Approaches for Clustering with Cluster-Based Feature Selection
Cem Iyigun, Middle East Technical University, Inonu Blvd, Endustri Muhendisligi, Ankara, 06800, Turkey, Sena Onen Oz

In this study, we work on a clustering problem where it is assumed that the features identifying the clusters may differ for each cluster. Number of clusters and number of relevant features in each cluster are given in advance. A center-based clustering approach is proposed. Finding the cluster centers, assigning the data points and selecting relevant features for each cluster are performed simultaneously. A non-linear mixed integer mathematical model is proposed which minimizes the total distance between data points and their cluster center by using the selected features for each cluster. Different linearization methods have been used for solving the problem. Besides, two different heuristic algorithms have been developed by taking into account the nature of the mentioned problem. Experimental results have been presented.

■ SA08

CC- Room 211

Applied Probability

Contributed Session

Chair: Ehsan Salimi, University of Florida, Gainesville, FL, 32603, United States

1 - Optimal Scheduling of Critically Loaded Multiclass Many-server Queues with Service Interruptions
Yi Zheng, The Pennsylvania State University, State College, PA, United States, Ari Arapostathis, Guodong Pang

We study optimal control problems for multiclass many-server queues with asymptotically negligible service interruptions in the Halfin-Whitt regime. The arrival process is a renewal process, and the random environment is an alternative renewal process. We show that the limits of diffusion-scaled processes are controlled jump diffusions with compound Poisson jumps. By constructing auxiliary processes and suitable Lyapunov functions, we establish long-run average moment bounds of the diffusion-scaled process with different abandonment rates under some scheduling policies. We prove the asymptotic optimality of the infinite-horizon discounted and long-run average (ergodic) problems.

2 - Sample Path Large Deviations for Shot Noise Processes in the High Intensity Regime
Lan Jin, Pennsylvania State University, University Park, PA, United States, lxj84@psu.edu, Guodong Pang

We prove the sample path large deviation principles for shot noise processes in the high intensity asymptotic regime, where the arrival rates are scaled up while time is unscaled. The arrival process is assumed to satisfy an LDP, including renewal processes as a special case. The noises are assumed to be i.i.d. with a general distribution. The shot shape function includes the multiplicative models and indicator functions. The good rate function requires solving a path-dependent optimization problem. This is distinct from the LDPs in the conventional asymptotic regime, where the space and time are both scaled.

3 - Use of Generalized Additive Models in the Estimation of Non-homogeneous Discrete Markov Chains, Applications in Multi-state Modeling of Health Status
Sebastián Felipe Calcetero, Universidad de los Andes, Bogota, Colombia, sf.calcetero674@uniandes.edu.co

Non-homogeneous DTMCs requires the estimation of a probability matrix for each possible age of the process, which is a very complex task in statistical terms. In this paper, we discuss the application of generalized additive models for the parsimonious estimation of the several transition probabilities, with the possibility of including profiling variables, dynamic behaviors and perform statistical inference. Finally, we illustrate the methodology for the estimation of dynamic life tables with portfolio experience and multi-state models for health status, using real data from a health insurer.

4 - Managing Capacity in Face of Uncertainty
Melda Ormeci Matoglu, University of New Hampshire, Durham, NH, United States, melda.ormecimatoglu@unh.edu, John Vande Vate, Haiyue Yu

We solve a generalization of the classic average cost Brownian control problem in which a controller dynamically controls the drift rate of a diffusion process. At each instant, the controller chooses the drift rate from available set of rates and can invoke instantaneous controls to keep the process from falling or to keep it from rising. We minimize the long-run average cost consisting of holding or delay costs, processing costs, costs for invoking instantaneous controls and fixed costs for changing the drift rate. We provide necessary and sufficient conditions on the cost parameters to ensure the problem admits a finite optimal solution and the form and parameters of an optimal policy when it exists.

5 - Local Moment Matching in Dynamic Programming Approximations

Amy B.Z. Zhang, Cornell University, New York, NY, United States, Itai Gurvich

Approximate dynamic programming is a family of algorithms designed to overcome the curse of dimensionality that is inherent to standard solution methods like value or policy iteration. Aggregation is one family of approximation method, but limited results are available beyond the special case of hard aggregation. We make the connection of aggregation to a sister chain to derive theoretical guarantees, and based on it, develop a disciplined way to determine the aggregation structure. The main foundation of this algorithm rests on matching local transition moments, as a result of applying Taylor function approximation.

6 - A Typical Set Approach to Longest Common Subsequence (LCS) Problems

Ehsan Salimi, University of Florida, Gainesville, FL, United States

The longest common sub-sequence (LCS) problem searches for the longest sub-sequence that is common to all given sequences, where the common sub-sequence is not necessarily repeated in the consecutive positions within the all sequences. Commonly used in bioinformatics, it searches for the closest common ancestors by comparing two DNA sequences. In this talk, we approach this problem from probabilistic point of view, introducing a new statistical framework for this problem. We utilize the notion of typical sequence borrowed from the information theory literature. An asymptotic bound on the maximum length of such sub-sequences are proposed under different underlying distributions.

■ SA09

CC- Room 212

Analytics and Optimization Approaches in Production and Service

Sponsored: Artificial Intelligence

Sponsored Session

Chair: Nooshin Hamidian, University of Tennessee-Knoxville, University of Tennessee-Knoxville, Knoxville, TN, 37920, United States

1 - Modeling and Analysis of Cascading Disruptions in Chain Network: A Cascading Simulation Model

Jafar Namdar, PhD, University of Iowa, Iowa city, IA, United States, Kang Zhao, Sadjad Anzabi Zadeh, Jennifer Blackhurst

Supply chain networks have extremely interconnected structures and due to the complex integration of the nodes (facilities) in the network, the failure of a single node might trigger extremely large scale failures and destroy a considerable part of the overall network. Thus, the firm's robustness to disruptions depends on the topology of supply chain structure. Our main goal in this study is providing the understanding regarding node characteristics and disruption propagation in the supply chain network through cascading failures. We simulated 13 different real-world supply chain network which are different in terms of size, echelons and products.

2 - Renewable Energy in Production Scheduling: A stochastic Approach

Samuel Trevino Martinez, PhD, University of Tennessee at Knoxville, Knoxville, TN, United States, strevin1@vols.utk.edu

Existing data points out that power interruptions in the United States can last up to 40 hours under major events affecting businesses and costing millions of dollars in losses. In light of the above, an optimal stochastic framework for production scheduling of a single machine is presented integrating on-site solar photovoltaic (PV) sizing decisions to mitigate energy disruptions and ultimately minimize energy and operational costs. To this end, a preliminary big data science is performed to estimate the random behavior of power frequency interruptions and duration, along with the finite random power availability from solar PV under different scenarios.

3 - Incentivizing Good Drivers: A New Data-driven Optimization Approach for Insurance Premiums

Masoud Barah, Northwestern University, University of Tennessee, Evanston, IL, United States

Incentivizing a driver with good driving behavior is a long-established agenda in the insurance business. However, insurance providers may not incentivize those drivers with appropriate lower insurance premiums. This research proposes a distributionally robust optimization framework to determine insurance premiums of transportation company drivers. Specifically, given a bulk discount offered by the insurance provider to the transportation company, the proposed framework produces a solution that assigns a discount rate to the transportation company's drivers with good driving records. We conduct a case study to evaluate the performance of the framework and provide analyses and insight.

4 - Simultaneous Detection of Adverse Drug Reaction and At-Risk Groups

Nooshin Hamidian, University of Tennessee-Knoxville, Knoxville, TN, 37920, United States, nhamidia@vols.utk.edu, Wenjun Zhou, Rapinder Sawhney

Association mining in high-dimensional data has been a core problem in data mining. While effectively measuring the association between item pairs has been challenging, studying the interplay among multiple factors is even more perplexing. In particular, association patterns discovered at the global level may not be consistent with its counterpart in a local segment. In this paper, we focus on the application of detecting adverse drug reactions that may not be visible at the global level, and we need to identify local segments in which the association between drugs and adverse reactions are strong. This will help identify conditions under which those patients are facing elevated risk.

■ SA10

CC- Room 213

Joint Session DAS/Practice Curated: Public Policy

Sponsored: Decision Analysis

Sponsored Session

Chair: Jonathan W. Welburn, RAND Corporation, RAND Corporation, Pittsburgh, PA, 15213, United States

1 - Analytical Method for Assessing Army Readiness, Risks, and Opportunity

Katharina Ley Best, Operations Researcher, The RAND Corporation, Pittsburgh, PA, 15217-1452, United States, Igor Mikolic-Torreira

Readiness implies the ability to generate trained, equipped, and manned forces as required for military operations. We introduce a novel way of quantifying one aspect of readiness, namely the ready forces that are likely to be available. This work simplifies the many dimensions of readiness into metrics related to the number of available units. The first simplification is common in the literature and suggests that force sufficiency based on "readiness ratios" can serve as a proxy for overall readiness. The second simplification is novel and reduces the output of such force sufficiency analysis to two simple metrics: the number of ready units and the number of potential additional ready units.

2 - Exploring Strategies to Optimize Technology Progression in Nasa's Small Business Innovation Research Program

Jeremy Eckhause, RAND Corporation, Arlington, VA, 22202, United States, eckhause@rand.org, Andrea Belz, Richard Terrile, Fernando Zapatero

Projects funded in NASA's two-stage Small Business Innovation Research (SBIR) program start at various Technology Readiness Levels (TRLs). Building from prior analysis generating realistic transition probability distributions from empirical data, we model funding strategies under the objective function that optimizes the expected number of projects achieving specific technology advancement, as well as accounting for grantee firm size. Our results highlight the role of optimizing each phase's budget and using a real options portfolio approach to maximize program outcomes.

3 - Bringing Evidence-based Decision Making to the Public Sector

Kara M. Morgan, Ohio State University, Dept. of Food Science and Tech, Parker Food Science and Tech, Columbus, OH, 43210, United States, kmmorgan42@gmail.com

Decision analysis has been a recognized field for over 50 years, but knowledge of research in decision making is not broadly understood. Further, although "evidence-based" is a new mantra for many interventions funded by the government, evidence-based decision-making methods have not been demanded. Use or even awareness of DA in the public sector is not common. This session will review the existing literature using DA for public sector decision making. This session will also begin to define, based on existing research, what a good decision process looks like for the public sector.

4 - Systemic Risk in the Broad Economy

Jonathan W. Welburn, RAND Corporation, Santa Monica, CA, 15213, United States, Aaron Strong, Justin Grana, Osonde Osoba, Florentine Eloundou, Claude Messan Setodji

In the years following the 2008 crisis, significant attention has been placed on systemic risk within interbank networks. However, little attention has been placed on systemic risks in the economy at large. Using an interdisciplinary approach that applies methods from economics, data science, and network analysis, we address this gap by estimating the network of firm-to-firm connections that occurs across business sectors within the broad U.S. economy. We expose heavily interconnected firms and identify areas of significant risk to the aggregate economy. The contributions of this work produce policy insights for managing risks ranging from economic crises to natural and manmade disasters.

■ SA11

CC- Room 214

Prosocial Behavior in Online Platforms

Sponsored: Social Media Analytics

Sponsored Session

Chair: Xue Tan, Indiana University, Bloomington, IN, 47405, United States

1 - The Impact of Online Platforms on Social Integration: Evidence from a Large-scale Volunteer Network

Yifan Yu, University of Washington, UW, Seattle, WA, United States, Xue Tan, Yong Tan

Social integration refers to the principles by which individuals or actors are related to one another in a society. Individuals participate more actively in collective actions under a high level of social integration. A critical indicator of social integration is the engagement of volunteering behavior. Based on a whole network of volunteers and volunteering organizations, this paper models the process of social integration and examines the impact of an online system that allows individuals to see a wider spectrum of volunteering projects. The paper has important managerial implications for online volunteer platforms.

2 - Temporal Dynamics and Diversity of Platform Groups: An Empirical Study on Kiva

Yue Jiao, University of Massachusetts Lowell, Lowell, MA, 06028, United States, Brian Lee

Self-organizing groups are commonly used as a means of engaging users in online platforms. We examine how self-organizing groups may affect user engagement in online platforms over time using a dataset from a crowdfunding platform Kiva.org. Leveraging the exogenous shock introduced by the platform, we show that the direction and magnitude of the group effect both depend on the tenure of a user joining a group. In addition, the contributing patterns of the group and the users have a significant impact on the platform group effect. Our results have important practical and theoretical implications.

3 - The Effects of Sponsored Videos on Facebook

Stephanie Lee, University of Washington, Foster School of Business, Seattle, WA, 98195, United States, stelee@uw.edu, Shahryar Doosti

Sponsored videos on social media have experienced a dramatic market growth. We study the effect of the creator-sponsor association on viewership and user engagement for videos on Facebook. We identify multiple aspects of creator-sponsor association and investigate their effect on the overall user engagement. First, we find that sponsorship leads to 65% reduction in views. While the industry category similarity has no significant effect on the sponsored views and engagements, both content similarity and audience overlap have positive effect on the performance measures. We conclude that the relevance between the creator and sponsor mitigates the negative effect of sponsorship on social media.

4 - Attention or Appreciation? The Impact of Computer-mediated Feedback on Online Volunteering

Fujie Jin, Kelley School of Business, Indiana University, Bloomington, IN, 47401, United States, Xue Tan, Alan R. Dennis

In this study, we examine how different types of feedback influence subsequent online volunteer contributions. We study a unique context of college application online consultation which requires the volunteer counselor and the person receiving help to be online at the same time. We investigate the impact of two types of feedback on volunteers' participation: 1) appreciation, as reflected in the number of positive ratings received by a counselor from counselees; 2) attention, as reflected in the readership of counselor's profile pages. We find that appreciation encourages the volunteer counselor to engage in more helping behavior, in contrast, attention discourages counselors to offer more help.

5 - Run for the Group: The Impacts of Offline Teambuilding, Social Comparison and Competitive Climate on Group Physical Activity - Evidence from a Mobile Fitness App

Jennifer Jie Zhang, University of Texas at Arlington, Arlington, TX, 76019, United States, Zilong Liu, Yuan Zhang, Xiaolong Song

To study the impacts of the within-group social comparison and between-group competitive climate on the group psychical activities, we conducted empirical analyses based on a dataset from a fitness app to test the main and moderating effects. Our results show that both the within-group social comparison and the between-group competitive climate can improve the group psychical activity.

■ SA12

CC- Room 2A

Queueing and Learning

Sponsored: Applied Probability

Sponsored Session

Chair: Weina Wang, Carnegie Mellon University, Pittsburgh, PA, c15213, United States

1 - Almost Bolzmann Exploration

R. Srikant, University of Illinois at Urbana-Champaign, Urbana, IL, United States, rsrikant27@gmail.com

Boltzmann exploration is a widely-used technique in machine learning to provide a tradeoff between exploration and exploration. However, it is also known to perform poorly in many examples of multi-armed bandit problems due to a well-known under-exploration issue. We present a modification to Boltzmann exploration which solves the under-exploration problem and show that it performs well in practice in many large data sets. Joint work with Harsh Gupta, Seo Taek Kong, and Weina Wang.

2 - Simple Near-optimal Scheduling for the M/G/1

Ziv Scully, Graduate Student, Carnegie Mellon University, Pittsburgh, PA, United States, zscully@cs.cmu.edu

We consider preemptively scheduling jobs to minimize mean response time in the M/G/1. If we know the job size distribution but not individual job sizes, the Gittins policy is optimal, but it can be very difficult to implement. A potential alternative to Gittins is shortest expected remaining processing time (SERPT), but it is unknown how far SERPT is from optimal. We present a new policy, monotonic SERPT (M-SERPT), which is as simple as SERPT but has provably near-optimal mean response time. Specifically, we prove that M-SERPT is 3-competitive for load up to 8/9 and 5-competitive for any load. This makes M-SERPT the first policy other than Gittins known to be constant-competitive for mean response time.

3 - Concentration Bounds for Constant Step-size Temporal Difference Learning

Lei Ying, Arizona State University, Tempe, AZ, 85287, United States, lei.ying.2@asu.edu, R. Srikant

We consider constant step-size temporal difference learning with linear function approximation, and study the concentration of the parameter values Θ around the corresponding ODE equilibrium point $\theta^*.$ Given a constant step-size, we show hat the (2n)th moment of ||Θ-θ^*|| is Gaussian-like when n=o(1/step-size) but is unbounded at steady state when n=ω(1/step-size).

4 - Heavy-traffic Analysis of the Generalized Switch under Multidimensional State Space Collapse

Daniela A. Hurtado-Lange, Georgia Tech, Atlanta, GA, United States, d.hurtado@gatech.edu

The generalized switch is a queueing model that encapsulates several Stochastic Processing Networks. We study the generalized switch operating under MaxWeight algorithm in heavy-traffic regime, using the drift method. In particular, we study the case when the Complete Resource Pooling condition does not hold, i.e. the state space collapses into a multi-dimensional space. We prove that the state space of the system collapses to cone and use this to exactly characterize the mean of certain linear combinations of the queue lengths in heavy-traffic. This work builds upon and generalizes the results obtained by Eryilmaz and Srikant (2012) and Maguluri and Srikant (2016).

■ SA13

CC- Room 2B

From Stochastic Control to Data-Driven Decision Making

Sponsored: Applied Probability

Sponsored Session

Chair: Renyuan Xu, University of California-Berkeley, Berkeley, CA, 94720, United States

1 - Learning Mean-Field Game

Xin Guo, University of California-Berkeley, Piedmont, CA, 94611, United States, xinguo@berkeley.edu, Renyuan Xu, Anran Hu, Junzi Zhang

Motivated by the Ad auction problem for advertisers, we consider the general problem of simultaneous learning and decision-making in a stochastic game setting with a large population. We formulate this type of games with unknown rewards and dynamics as a generalized mean-field-game (GMFG), with incorporation of action distributions. We first analyze the existence and uniqueness of the GMFG solution, and show that naively combining Q-learning with the three-step fixed-point approach in classical MFGs yields unstable algorithms. We then propose an approximating Q-learning algorithm and establish its convergence result. The numerical performance shows superior computational efficiency.

2 - Continuous-Time Mean-Variance Portfolio Selection: A Reinforcement Learning Framework

Xunyu Zhou, Columbia University, Department of IEOR, New York, NY, 10027, United States, Haoran Wang

We approach the continuous-time mean-variance (MV) portfolio selection with reinforcement learning (RL). The problem is to achieve the best tradeoff between exploration and exploitation, and is formulated as an entropy-regularized, relaxed stochastic control problem. We prove that the optimal feedback policy for this problem must be Gaussian, with time-decaying variance. We then prove a policy improvement theorem, based on which we devise an implementable and data-driven RL algorithm. We find that our algorithm outperforms both an adaptive control-based method and a deep neural networks-based algorithm by a large margin in our simulations.

3 - A Unified Framework for Solving High-Dimensional Parabolic PDEs and FBSDEs with Deep Learning

Jiequn Han, Princeton University, Princeton, NJ, United States

We introduce the "deep BSDE method" as a unified framework to solve general high-dimensional parabolic PDEs and FBSDEs. Starting from the BSDE formulation, we approximate the unknown component by neural networks and design a least squares objective function to optimize parameters. Numerical results of a variety of examples demonstrate that the proposed algorithm is quite effective in high-dimensions, in terms of both accuracy and speed. We furthermore provide a theoretical error analysis to illustrate the validity and property of the objective function.

4 - Linear-quadratic Mean Field Type Reinforcement Learning

Mathieu Lauriere, Princeton University, 98 Charlton Street, Princeton, NJ, 08540, United States, lauriere@princeton.edu, Rene A. Carmona, Zongjun Tan

In this work, we develop reinforcement learning methods for mean field type control problems (also called problems of optimal control of McKean-Vlasov dynamics). Such problems arise, for instance, either when a single agent interacts with her own distribution or as the limit of games with a large number of collaborative agents when the number of agents goes to infinity. We prove global convergence of a policy gradient method in a linear-quadratic setting and provide numerical experiments. If time permits, other settings and methods will be discussed. Joint work with Rene Carmona and Zongjun Tan.

■ SA14

CC- Room 302

Analytics for E-commerce Operations

Sponsored: Manufacturing & Service Oper Mgmt

Sponsored Session

Chair: Jing-Sheng Jeannette Song, Duke University, Durham, NC, 27708-0120, United States

Co-Chair: Shuyu Chen

1 - Randomized Product Display, Pricing, and Order Fulfillment for E-commerce Retailers

Murray Lei, Queen's University, Kingston, ON, K7L 3N6, Canada, yl64@queensu.ca, Stefanus Jasin, Joline Uichanco, Andrew Vakhutinsky

Consider an etailer selling multiple products stored in multiple warehouses to customers from multiple regions. For each customer, etailer may customize the pricing decision, the product display decision (i.e. which products to display in what manner on the website), and the fulfillment decision (i.e., where to dispatch individual items). We propose a tractable LP formulation and then construct a novel randomization scheme that translates the solutions to the LP into control parameters. We test the performance of the proposed control in large-scale numerical experiments with real retail data.

2 - The Operational Value of Personalized Return Policies in Retail

Aravind Govindarajan, Ross School of Business, University of Michigan, Ann Arbor, MI, 48104, United States, arav@umich.edu, Joline Uichanco, Hyun-Soo Ahn

The problem of customer returns is prevalent in modern retail where lenient return policies are popular; however, several customers take advantage of such policies, which leads to loss in revenue and increase in inventory costs. We study the value of personalizing return policies based on a customer's historical behavior. For a heterogeneous mass of customers, we derive the optimal personalized return policy and show that the knowledge of customer-specific information can help the firm strategically offer return policies to increase inventory efficiency.

3 - Data-driven E-commerce Transportation Network Design with Unknown Flow Response

Shuyu Chen, Duke University, Durham, NC, 27701, United States, shuyu.chen@duke.edu, Jing-Sheng Jeannette Song

We study a network design problem for an e-commerce marketplace. One novel feature in our model is that the decision maker has no control over flow decision once the network configuration is decided. We develop a flow prediction model using observational data and then embed it into the fixed-charge network design problem. The problem is NP-hard but can be characterized as a c-submodular maximization problem. We propose two linear time approximation algorithms to solve it.

4 - Understanding the Value of Fulfillment Flexibility in an Online Retailing Environment

Levi DeValve, University of Chicago, Chicago, IL, 27713, United States, Yehua Wei, Di Wu, Rong Yuan

We assess the value of partial flexibility in online retailing fulfillment networks. Motivated by practical constraints, we propose an intuitive spillover limit policy that is asymptotically optimal as the time horizon and inventory grow large. Motivated by the revenue management literature, we also derive the optimal spillover limits in a simplified model in the non-asymptotic regime and show that these spillover limits perform well numerically. Using this policy, we estimate a significant cost decrease for our industrial collaborator.

■ SA15

CC- Room 303

Healthcare Operations

Sponsored: Manufacturing & Service Oper Mgmt

Sponsored Session

Chair: Lauren Xiaoyuan Lu, University of North Carolina at Chapel Hill - Kenan Flagler, Chapel Hill, NC, 27599, United States

Co-Chair: Susan F. Lu, Purdue University, West Lafayette, IN, 47907, United States

1 - An Empirical Study of On-demand Healthcare Platforms

Yixuan Liu, The University of Texas at Austin, Austin, TX, 78712, United States, Ashish Agarwal, Guoming Lai, Weihua Zhou

On-demand healthcare platforms allow patients to seek care from distributive healthcare providers, targeting the problems of healthcare resource misuse and mismatch. Collaborating with a mobile platform in China, we conduct an empirical study of healthcare platform design problem. We evaluate the effects of providing free service sampling on users' behaviors of purchasing premium services across geographical regions and disease categories. We find that there coexist cannibalization effects and acceleration effects.

2 - Consumer Online Reviews, Government Ratings and Nursing Home Operations: Evidence from Yelp

Yuanchen Li, Purdue University, West Lafayette, IN, 47906, United States, li1820@purdue.edu, Susan F. Lu, Lauren Xiaoyuan Lu

We study the effect of user-generated reviews on nursing homes' performance in the presence of government ratings. Employing the Yelp nursing home rating matched with OSCAR dataset from 2010 to 2017, we conduct a difference-in-differences analysis on nursing homes' financial performance and patient volume. We observe that a one-star increase in Yelp rating leads to a 1.9% increase in revenue. Our empirical analysis suggests that facilities increase their revenue by chasing more Medicare-covered patients while filtering Medicaid-covered patients.

3 - Effect of Multi-siting on Productivity and Quality

Diwas S. Kc, Emory University, Goizueta Business School, Atlanta, GA, 30322, United States, Sokol Tushe

Although multi-site workplace deployment is becoming increasingly common, its impact on people operations has not been examined in the operations management literature. We contribute to the literature by studying the effect of multi-siting on individual worker productivity and quality of output.

4 - Increasing Patient Engagement Through Shared Medical Appointments

Ryan Buell, Harvard Business School, Boston, MA, 02163, United States, rbuell@hbs.edu, Kamalini Ramdas, Nazli Sonmez

Through a randomized control trial, we examine the impact of shared medical appointments (SMAs), in which a group of patients with similar chronic conditions meet with a doctor simultaneously, on levels of patient engagement. Relative to traditional one-on-one care models, we study how SMAs affect engagement levels, both during the appointment (such as making eye contact with the physician, engaging in the proceedings, and asking questions) and after (such as complying with prescribed medications in the home). Preliminary evidence suggests that SMAs have the potential to increase patient engagement, both during and after the appointment, hinting at their potential to improve patient outcomes.

■ SA16

CC- Room 304

Operations for Knowledge-Intensive Services

Sponsored: Manufacturing & Service Oper. Mgmt/Service Operations

Sponsored Session

Chair: Guillaume Roels, INSEAD, Fontainebleau, 77305, France

1 - Service Designs as Quality Signals

Stylianos Kavadias, Margaret Thatcher Professor of Innovation & Growth, University of Cambridge, Judge Business School, Trumpington Street, Cambridge, CB2 1AG, United Kingdom, s.kavadias@jbs.cam.ac.uk, Ioannis Bellos

We follow up on prior work to conceptualise service designs as choices of how much of a customer journey should a service provider control. We consider, however, an asymmetry of information setting where the customers cannot be entirely sure about the service provision capability of a company. We analyse whether a service provider can use the amount of control as a signal of their quality in the market and we find that depending on the type of service more, or less, control is optimally chosen for the design. Our results have direct implications for new service design contexts.

2 - Effects of Mental Accounting on Project Performance

Manel Baucells, University of Virginia, Charlottesville, VA, United States, BaucellsM@darden.virginia.edu, Yael Grushka-Cockayne, Woonam Hwang

Projects often fail to meet their goals. We consider the implications of behavioral tendencies, both at launch and at the revision points, on decisions made and on overall project performance. Specifically, we offer a framework for modeling mental accounting—which includes loss aversion and reference point updating—and narrow framing. We show that mental accounting results in insufficient adjustments of project scope and cost during revisions and prevents abandoning projects even when doing so is optimal. We offer practical prescriptions for mitigating harmful effects of loss aversion, reference-point updating, and narrow framing.

3 - Complain About Too Many Meetings? Performance of Meeting Schedules for Team Coordination

Charles J. Corbett, University of California-Los Angeles, Anderson Graduate School of Mgmt, Los Angeles, CA, 90095-1481, United States, Guillaume Roels

In many knowledge-intensive operations (e.g., coding), workers produce individually but may benefit from periodic coordination with the others. As they keep producing, they encounter issues, which negatively impact their individual productivity, but can be resolved through a collective meeting. With a game-theoretic model, we evaluate different meeting schedule business rules: deterministic meeting schedule, preemptive coordination (i.e., coordination happens as soon as one worker wants to coordinate), and preemptive production (i.e., production happens as long as one worker wants to produce).

4 - New Venture Creation: a Drift-variance Diffusion Control Model

Zhengli Wang, Stanford University, Stanford, CA, 94305, United States, Stefanos Zenios

We model the creation of a new venture with a diffusion process, where an entrepreneur can control the drift and the variance of the process. The entrepreneur receives a huge reward or goes bankrupt, depending on whether the process reaches the upper boundary or the lower boundary. We characterize the optimal policy and show how the optimal policy depends on the model primitives.

■ SA17

CC- Room 305

Joint Session MSOM/SERV OP/Practice Curated: Empirical Studies in Health and Service Operations

Sponsored: Manufacturing & Service Oper. Mgmt/Service Operations

Sponsored Session

Chair: Fanyin Zheng, Columbia University, New York, NY, 10027, United States

Co-Chair: Carri Chan, Columbia Business School, New York, NY, 10027, United States

1 - Tax-induced Inequalities in the Sharing Economy

Yao Cui, Cornell University, Ithaca, NY, 14853, United States, yao.cui@cornell.edu, Andrew M. Davis

We use a machine learning method (generalized causal forest) to study the heterogeneous treatment effects of the tax policy on Airbnb. While the tax regulation is intended to alleviate the pressure that Airbnb creates to hotels, we find that it has led to unintended consequences for Airbnb participants. In particular, the tax policy adversely affects residential listings more than commercial listings, and adversely affects those listings whose service offerings are more differentiated from hotels. These distributional impacts indicate that the goal of the tax policy is not effectively achieved. We further provide insights to policy makers and sharing economy platforms regarding tax regulation.

2 - A Structural Estimation Approach to Study Agent Attrition

Seyed Emadi, UNC-Chapel Hill, Chapel Hill, NC, United States, seyed_emadi@kenan-flagler.unc.edu, Bradley R. Staats

We build a structural model that captures both the firm’s decision to terminate a workers’ employment (involuntary attrition) and uses an optimal stopping problem process to model a workers’ decision to leave the firm (voluntary attrition). We then estimate the parameters of the model and conduct counterfactual analyses on the population of 1,118 agents serving one client over three years for an Indian business process management (BPM) company.

3 - Scheduling of Primary Care Follow Up and Risk of Long Term Opioid Use

Katherine Bobroske, University of Cambridge, Trumpington Street, Cambridge, CB2 1AG, United Kingdom, kab80@jbs.cam.ac.uk, Lawrence Huan, Michael Freeman, Anita Cattrell, Stefan Scholtes

Many patients are initially prescribed opioids in the primary care setting. While clinical guidelines promote continuity of care for managing opioids, little is known about whether this recommendation is effective in the early stages of a patient’s opioid journey. We analyzed the medical claims of opioid-naive patients who received their first opioid prescription in a primary care office setting. Using data mining and econometric methods, we found that exposing patients to a second medical opinion early in their opioid journey may significantly curb rates of long-term opioid use.

4 - Structural Estimation of Intertemporal Externalities on ICU Admission Decisions

Yiwen Shen, Columbia Business School, New York, NY, 10025, United States, YShen21@gsb.columbia.edu, Carri Chan, Fanyin Zheng

The ICU in a hospital often has the highest cost and congestion level. Since a large proportion of the patients in ICU are the patients admitted from the Emergency Department (ED), we can gain insights on how physicians make ICU admission decisions and how to improve overall outcomes by studying the ED physicians’ ICU admission decisions. Our study focuses on the intertemporal externalities on these ICU admission decisions. We take the structural estimation approach to estimate the intertemporal externalities from data. We use two years of detailed patient-level data from 21 Kaiser hospitals. We find that there is substantial heterogeneity in the estimated discount factor across hospitals.

■ SA18

CC- Room 306

Operational Innovations and Innovative Operations

Sponsored: Manufacturing & Service Oper. Mgmt/Supply Chain

Sponsored Session

Chair: Vish Krishnan

1 - An Investigation of Drug Shortage Recovery

Junghee Lee, Tulane University, New Orleans, LA, 70118, United States, jlee56@tulane.edu, Hyun Seok (Huck) Lee, Hyoduk Shin, Vish Krishnan

Ongoing shortages of pharmaceutical drugs in the U.S. have critically threatened public health. As the primary reason for the shortages is manufacturing related issues, how soon the shortage is resolved depends on the firm’s investment in recovering its production line. We investigate the effects of various features of drugs on this firm’s decision through time-to-recovery (TTR) in conjunction with the intervention of the Food and Drug Administration (FDA) which aims to lower “entry cost” particularly for drugs in short supply. We find that the TTR of drugs with low (high) economic incentives is longer (shorter) and becomes even longer (shorter) after the intervention.

2 - Pooled Transportation: Consumer Preferences and System Design

Kashish Arora, Cornell Tech/Johnson, New York, NY, United States, ka522@cornell.edu, Karan Girotra, Fanyin Zheng

Pooled ride services alleviate the problems of traffic congestion and air pollution. This study builds a structural model to estimate drivers of choices between an on-demand taxi service and a pre-determined and scheduled shuttle service. Using large scale data from a transportation service provider, we estimate the ``inconvenience costs” to customers associated with the shuttle service (walking to the shuttle, waiting for its arrival, and traveling extra distance on the shuttle). We then use these estimates to quantify the environmental benefits of the shuttle service and provide policy recommendations for designing the pricing scheme and introducing new routes for the shuttle service.

3 - Managing Exploration and Execution

Sina Moghadas, University of California San Diego, San Diego, CA, United States, Lakshminarayana Nittala, Viswanathan Krishnan

We consider the design of innovation contests while conceptualizing solution development as an incremental process involving idea generation and implementation. Such a perspective provides extra levers to the seeker, which, when managed optimally, can increase the returns to the seeker by increasing the chances of realizing high quality feasible solutions.

4 - Does Real-time Feedback Make You Try Less Hard? A Study of Automotive Telematics

Vivek Choudhary, INSEAD Business School, Singapore, vivek.choudhary@insead.edu, Maria Shunko, Serguei Netessine

IoT devices increasingly enable tracking of user behavior and they often provide real-time feedback to the consumers in an effort to improve their conduct. Growing adoption of such technologies leads to an important question, “Does real-time feedback provided to users improve their behavior?” We study real-time feedback in the context of automotive telematics that has been recognized as the most disruptive technology in the automotive insurance industry. Contrary to much of the existing feedback literature, we find that, on average, the driving performance of users post-detailed feedback is 13.3% worse than the performance of users who do not review their detailed feedback.

■ SA19

CC- Room 307

Manufacturing

Sponsored: Manufacturing & Service Oper. Mgmt/Supply Chain

Sponsored Session

Chair: Robert Louis Bray, Kellogg School of Management, Northwestern University, Evanston, IL, 60202, United States

Co-Chair: Juan Camilo Serpa, Indiana University, Montreal, QC, H2L 3S2, Canada

1 - Manufacturing Productivity with Worker Turnover

Ken Moon, The Wharton School, Philadelphia, PA, United States, kenmoon@wharton.upenn.edu

We investigate turnover’s effects on manufacturing productivity using data from China-based facilities producing millions of electronic goods weekly yet exhibit worker turnover exceeding 300% annually. Worker turnover significantly disrupts the productivity of responsive manufacturers facing uncertain product demand. We extend production planning to include endogenous worker turnover as an Experience-Based Equilibrium and use reinforcement learning and approximate DP to estimate and simulate our model. Well-calibrated increases to worker compensation reduce production costs by at least 5%, or $135M, by stabilizing a leaner workforce and improving the reliability of production.

2 - When to Be Agile

Amandeep Singh, The Wharton School, Philadelphia, PA, 19104, United States, amansin@wharton.upenn.edu, Kenneth Moon, Gad Allon

Mobile apps release version updates, motivating interest in agile operational responses to app store ratings. We characterize the optimal strategy for timing such updates and structurally estimate the extent to which developers are agile, exhibiting both reactive capacity and responsiveness to customer feedback. We discuss implications for platform design.

3 - The Value of Free Shipping: Field Experiment on O2o Platform

Yuqian Xu, University of Illinois at Urbana-Champaign, Champaign, IL, 61820, United States, Hongyan Dai, Yan Wen

In this paper, we aim to investigate the impact of free shipping on consumer behaviors in O2O platforms. More specifically, we want to study: (1) the impact of the free shipping and its magnitude on customer behaviors; (2) the impact of tipping behavior of the consumers on the crowd-sourced delivery staffs; (3) how free shopping promotion interactively affects tipping behavior. We collect field experiment data from one leading O2O platform in China to explore these questions.

4 - Supply Chain Structure and Contract Performance

Vibhuti Dhingra, University of British Columbia, Vancouver, BC, V6T1Z2, Canada, vibhuti.dhingra@sauder.ubc.ca, Harish Krishnan, Juan Serpa

In the US public projects, federal agencies award contracts to a prime recipient. In many cases, the prime contractor then outsources a significant proportion of the work to a network of subcontractors. Subcontractor misconduct can adversely impact contract performance leading to delays or cost overruns. As the government does not have privity of contract with the subcontractors, it cannot directly control their actions. Instead, the task of subcontractor oversight is given to the prime contractor. In this setting, we empirically examine the impact of multi-tier supply chain structure on contract performance.

■ SA20

CC- Room 308

Whose Project is it Anyway? Designing Industry Collaborations for Learning AND Impact

Sponsored: Education

Sponsored Session

Chair: Sanjay Saigal, University of California-Davis, Menlo Park, CA

1 - Lessons from Managing Student Consulting Projects

Vijay Mehrotra, University of San Francisco, 2130 Fulton St., School of Business and Professional Studies, San Francisco, CA, 94117, United States, vmehrotra@usfca.edu

For the past ten years, I have been supervising MBA student consulting projects in business analytics and related areas. In this session, I will share what I’ve learned along the way, including both pleasant and unpleasant lessons, offer some suggestions for best practices, and solicit input from the attendees. My intent is to have a highly interactive session with lots of dialogue.

2 - Capstone Projects: Learning from the “Real World” While Still in School

Scott Nestler, University of Notre Dame, Granger, IN, 46530, United States

The capstone project is the culmination of the MS in Business Analytics (MSBA) program and provides an intensive and integrative experiential-learning opportunity. Student teams work to analyze a problem on behalf of a sponsoring organization, which provides the business problem and gives students access to relevant data and in-house personnel. Using skills acquired throughout the program, students develop a thorough understanding of the problem and the associated data, then develop and execute a project work plan that analyzes the data, develops actionable recommendations and conclusions, and provides insight into the basis for those recommendations. Skills developed include the ability to provide effective communication regarding the analytics process and results, and an understanding of key aspects of analytics solution development.

3 - The Care, Feeding, and Nurturing of Unicorns

Raymond Pettit, UC San Diego, San Diego, CA, 92093, United States

Master’s degrees in business analytics claim to develop managerial, personal and communication skills beyond a data science core, in other words, to create “unicorns”. Programs often launch students into ‘sink or swim’ capstone projects that fulfill the letter but belie the spirit of such lofty goals. Guidance by a multi-faceted support team can enable a learning experience that advances the value of the degree and the student’s career. We describe the three-fold academic support team at UCSD that embeds technical, managerial, and communication training at each step of the capstone.

4 - Integrating Experiential Learning in Analytics Master’s Programs

Sanjay Saigal, Graduate School of Management, UC Davis, Menlo Park, CA, 94025, United States

Analytics graduate programs meet employment-focused outcomes through “learning-by-doing” activities - capstones, internships, and practicums. Deans hope that projects complement traditional course in OR, statistics, computing, etc. We ask: are such combinations of experiential and theoretical learning interventions stylistically coherent and pedagogically integrated? And do they increase employability? Using the experience of a new, practice-centric MS program in Business Analytics - its core is an intensive, nearly year-long, industry practicum - we answer those, and related, questions.

■ SA21

CC- Room 309

New Topics in Logistics, Manufacturing and Risk Management

Sponsored: Manufacturing & Service Oper. Mgmt/iFORM

Sponsored Session

Chair: Sebastian Maier, EPFL, Lausanne, 1015, Switzerland

1 - Choice-based Electric Vehicle Smart Charging: Discovering and Exploiting Latent Demand Flexibility

Nicolò Daina, Imperial College London, London, United Kingdom, n.daina@imperial.ac.uk

Traditional smart charging considers charging requests from electric vehicles (EV) drivers as fixed, neglecting potential additional demand flexibility from drivers with flexible charging and departure times preferences. We integrate into operations management of a charging service provider a negotiation phase in which flexible charging alternatives are presented to EV drivers. A choice-based optimisation approach is used to identify the offer set of charging alternatives and their pricing. We show the additional load flexibility potential of this approach in a simulation study based on published charging preference information and real-world charging demand data.

2 - Modeling Supply Change Disruptions via a Sequence of Optimized Regrets

René Yves Glogg, EPFL, Lausanne, 1015, Switzerland

We present a stochastic optimization problem that obtains a resilient production plan for a convex minimum cost network flow problem which models a simple supply chain. We do so by introducing a function into the optimization that models the regret a decision-maker incurs whenever some supply chain disruption scenario occurs. We adapt a generalized Benders decomposition approach in order to be able to solve this problem for sufficiently large instances and perform some managerial analysis on the results.

3 - Additive Manufacturing: Towards Flexible Operations and Profitable Mass Customization

Rachel Lacroix, PhD Candidate, EPFL, Lausanne, 1015, Switzerland, rachel.lacroix@epfl.ch, Anna Timonina-Farkas, Ralf W. Seifert

Technology enablers of Industry 4.0 paired with an increasing demand for product customization create a challenging push-pull situation for supply chains. We quantify the economic benefits of integrating additive manufacturing into existing mass production systems. Through customer-specific utilities, we derive an endogenous, time-varying demand and formulate an optimization problem to jointly optimize pricing, process-switching and product-variety decisions. Numerical experiments provide managerial insights to better satisfy individual customer preferences while maximizing profit.

5 - Risk-averse Pathwise Dynamic Programming: a Simple Simulation-and-regression Approach

Sebastian Maier, EPFL, Lausanne, 1015, Switzerland, Imperial College-London, London, United Kingdom, Georg Pflug

Pathwise dynamic programming is a powerful algorithmic strategy to solve sequential stochastic decision problems such as valuing options; however, existing valuation approaches generally neglect decision-makers' attitude towards risk. We propose an approach to solve risk-averse stochastic dynamic programs by simulation-and-regression. Applying the dynamic entropic risk measure, we use simulation in combination with parametric regression to approximate the conditional risk measure. Using the examples of put and call options, we investigate the way in which the option value is affected by risk aversion and illustrate its impact on both optimal decisions and the probability of investment.

■ SA22

CC- Room 310

Going the Extra Mile for Sustainable Supply Chains

Sponsored: Manufacturing & Service Oper. Mgmt/Sustainable Operations

Sponsored Session

Chair: Tarkan Tan, Eindhoven University of Technology, Eindhoven, 5612AZ, Netherlands

Co-Chair: Osman Alp, University of Calgary, Calgary, AB, T2N1N4, Canada

1 - Improving the Environmental Impact of E-commerce via Better Truck Consolidation

Josue Cuauhtemoc Velazquez Martinez, Massachusetts Institute of Technology, Cambridge, MA, United States, josuevm@mit.edu, Karla Gamez-Perez, Andres Mulos-Villamizar

With e-commerce companies (e.g. Amazon) move toward offering fast shipping options, we predict lower truck utilization and more frequency of home deliveries. As a consequence, transportation emissions are expected to grow significantly, having negative impact on the environment and human health. In this article, we study the evolution of home delivery in e-commerce. We conduct an econometric analysis for two of the largest cities in the US by considering urbanization, aging, income, GDP, internet accessibility, and shopping habits. We study the effect in transportation emissions during home delivery, and provide managerial insights for key stakeholders: Carriers, Consumers and Government.

2 - Information Asymmetry and Firm Non-compliance: Effective Policies in Waste Disposal

Sytske Wijnsma, University of Cambridge, Christ's College, Cambridge, CB23BU, United Kingdom, Dominique Lauga

Illicit waste disposal is one of the fastest growing areas in crime today. This paper examines the effect of waste regulations, intended to induce proper waste disposal, on firm non-compliance and its interaction with the underlying information structure. We find that decentralisation of the waste management chain, aggravating information problems, can either exacerbate non-compliance or improve economic and environmental outcomes. The allocation of enforcement efforts between firms and the orientation of these efforts between domestic and international regulations play a critical role in determining which outcome is attained.

3 - Efficient Supplier Assessment for Sustainability in Supply Chains

Tarkan Tan, Eindhoven University of Technology, School of Industrial Engineering, Den Dolech 2 Paviljoen F-07, Eindhoven, 5612AZ, Netherlands, t.tan@tue.nl, Hakan Akyüz

The last few decades have witnessed a complete globalization of supply chains, resulting in a typical Multi National Enterprise (MNE) having tens of thousands of suppliers in developing countries. Socioeconomic state of these countries lead to social, environmental, and ethical problems at factories which directly or indirectly supply goods and services to MNEs. To address this, the common practice by many MNEs is to assess the sustainability levels of their suppliers through means like audits or verified self-assessments provided by the suppliers. In this talk we address how this assessment can be conducted in an efficient manner, taking the supplier characteristics into account.

4 - Sustainable Fleet Management with Alternative Fuel Vehicles

Osman Alp, University of Calgary, Haskayne School of Business, Calgary, AB, T2N1N4, Canada, osman.alp@ucalgary.ca, Tarkan Tan, Maximiliano Udenio

We analyze a fleet management problem of a freight transportation company, which aims to adopt a fleet of sustainable vehicles in a finite planning horizon. In particular, we optimize the transformation of their fleet into a mixed fleet of electric and diesel trucks. Our model also optimizes for the choice of charging technology as well as the number of charging facilities and their capacities. The objective of the decision maker is to minimize the investment costs for vehicles and the charging infrastructure, and the carbon emission related costs. We present a numerical study to generate insights about how to facilitate and incentivize the adoption of sustainable vehicle technologies in practice.

■ SA23

CC- Room 3A

Operations and Supply Chain Management

Sponsored: Decision Analysis

Sponsored Session

Chair: Barry R Cobb, Virginia Military Institute, Lexington, VA, 24450, United States

1 - Library Book Shifting

Linda Li, Missouri State University, Springfield, MO, United States, Joshua D. Lambert

A mathematical programming model is built to efficiently use library shelf space when moving books. As a benchmark, we also suggest a myopic method. The comparison of the two methods is based on simulation, which uses empirical data.

2 - The Design Decision Supply Chain

Robert F. Bordley, PMP, MBA, University of Michigan Ann Arbor, Troy, MI, 48085, United States, rbordley@umich.edu

This paper focuses on eliminating the disconnect between strategic, tactical and operational decision-making using systems engineering. After a need is identified, the requirements for addressing the need are first defined at the system level, then the subsystem level and then the component level. Solutions are then developed at the component level, then the subsystem level and finally the overall level. This paper argues that this process for making designs can be used to define a value-focused decision supply chain for drawing on diverse skills and expertise for creating a detailed plan (or decision) to address fundamental objectives.

3 - Attribute Statistical Process Control with Limited Information

Barry R. Cobb, Virginia Military Institute, Department of Economics and Business, 344 Scott Shipp Hall, Lexington, VA, 24450, United States, cobbbr@vmi.edu

A limited memory influence diagram model is utilized for statistical process control in a system where attribute data on number of defects is available each sampling period. Based on the number of defects observed, a decision is made on whether to stop the process and repair an assignable cause of variation. The model has no requirement to maintain the history of sample results and/or corrective actions taken in previous sampling periods.

4 - Using Genetic Algorithms for Additive Production Scheduling

Maaz Saleem Kapadia, North Carolina State University, Raleigh, NC, United States, Reha Uzsoy, Donald Paul Warsing, Binil Starly, Alec Thomas

We study an additive manufacturing system that fulfills due-date-specific orders for custom parts with varying shapes, sizes, structures, and surface quality requirements. We use a genetic algorithm to determine part sequences and orientations that maximize profit for this system. Experiments in a simulated environment demonstrate that some implementations of the genetic algorithm exhibit significant advantages in terms of computational effort and system profitability.

■ SA24

CC- Room 3B

Advances in Multiobjective Optimization

Sponsored: Multiple Criteria Decision Making

Sponsored Session

Chair: Margaret M. Wiecek, Clemson University, Clemson, SC, 29634-1907, United States

1 - Generating Well-dispersed Nondominated Solutions for a Multiobjective SVM Formulation

Serpil Sayin, Koc University, Istanbul, Turkey, Gokhan Kirlik

We present a multiobjective L1-norm SVM formulation that treats sum of empirical errors for different classes as separate objective functions. We propose obtaining a representation of the nondominated set by solving a subproblem that is based on the achievement scalarizing function. The proposed approach does not provide quality guarantees on the representation that is delivered, and it relies on the ability of the achievement scalarizing function to target specific regions in the outcome set. We demonstrate that the approach can deliver good classifiers when applied to difficult imbalanced classification problems.

2 - Generalized Set Covering Problem with Conflict Objective Functions: Algorithm and Applications in Ecological Conservation

Lakmali Weerasena, University of Tennessee at Chattanooga, Chattanooga, TN, United States, lakmali-weerasena@utc.edu

In this research, we propose a generalization to the Set Covering Problem (SCP). We define the new problem as the generalized multi-objective SCP (GMOSCP) and propose an algorithm to approximate the Pareto set of the GMOSCP. Developing an algorithm to approximate the Pareto set of the GMOSCP is merited since it is a NP-hard problem. The performances of the algorithm are verified using a real data in ecological conservation and conflicting objective functions are proposed. Several experiments have been conducted to analyze the performance of the proposed algorithm. The results show that algorithm performs well and finds approximated solutions efficiently.

3 - Portfolio Optimization with Multiple Quadratic Functions

Margaret Wiecek, Clemson University, Clemson, SC, United States, wmalgor@clemson.edu

The classical mean-variance portfolio optimization problem is formulated as a multiobjective quadratic program (MOQP) and its efficient set is computed with a state-of-the-art algorithm for solving parametric linear complementarity problems with parameters in general locations (Adelgren, 2016). The MOQP is scalarized with a newly developed approach being a modification of the hybrid method (Wendell and Lee, 1977; Corley, 1980). The scalarization allows for quantifying tradeoffs for groups of objective functions which, in the case of the portfolio optimization, are the weighted risk and the return. A triobjective example is provided.

4 - A Solution Algorithm for Biobjective Mixed Integer Programming Problems

Ozlem Karsu, Bilkent University, Ankara, 06800, Turkey, ozlemkarsu@bilkent.edu.tr, Firdevs Ulus, Deniz Emre

We propose an objective space based exact solution algorithm for biobjective mixed integer programming problems. The algorithm solves scalarization models in order to explore predetermined regions of the objective space called boxes, defined by two nondominated points. The initial box is defined by the two extreme nondominated points of the Pareto frontier, which includes all nondominated points. At each iteration of the algorithm, a box is explored either by a weighted sum or a Pascoletti-Serafini scalarization to determine nondominated line segments and points. We demonstrate the applicability of the algorithm through computational experiments.

5 - Approximation Algorithms for the Multiple Knapsack Problem with Grouped Items

Pinar Keskinocak, Georgia Institute of Technology, School of Indust/System Eng, Atlanta, GA, 30332, United States, Francisco Javier Castillo Zunino

Motivated by patient scheduling, the multiple knapsack problem with grouped items aims to maximize profits by assign a subset of items among multiple knapsacks, without exceeding their capacities. Additionally, items are partitioned into groups where either all items in a group are assigned or none at all. We propose three algorithms for this problem that respectively solve: a linear relaxation, a knapsack problem, and a multi-dimensional knapsack problem. All solutions guarantee that profits are not less than the optimal solution but can exceed knapsack capacities. We finally test the performance of the algorithms on randomly generated instances.

■ SA25

CC- Room 401

Analytical Models in Marketing-Operations Interface

Emerging Topic: Interface of Marketing & Operations

Emerging Topic Session

Chair: Jeffrey Shulman, University of Washington, Seattle, WA, 98195-3226, United States

1 - Spot Pricing in Cloud Computing: Diversification of Cloud Resources under Supply Uncertainty

Amir Fazli, Indiana University, Bloomington, IN, United States

Cloud computing providers often sell their excess resources on a spot market, where resources could be interrupted at any time. In order to alleviate the effects of such interruptions, cloud providers offer spot users the option to diversify cloud resources across different server types. It is commonly believed that a diversified cloud strategy is used primarily when interruptions are highly likely. However, we show that when the value difference between spot users is moderately high, diversification occurs only when interruption likelihood is low. This is because an interruption in one pool can increase the price of the remaining pools when diversification is chosen.

2 - Competitive Pricing under Observational Learning

Amin Sayedi, University of Washington, Seattle, University of Washington, Seattle, Seattle, WA, 98195, United States

We look at the problem of pricing in a duopoly with observational learning. Prior literature shows that when the number of customers in a monopoly is sufficiently large and the monopolist is sufficiently patient, an informational cascade always happens; furthermore, the probability that the cascade is wrong, i.e., virtually all customers receive negative utility ex post, is always positive. We find similar results in a duopoly with static pricing. Interestingly, and in contrast to the previous literature, we show that in a duopoly with dynamic pricing, there are equilibria in which no cascade happens. More importantly, we show that a wrong cascade cannot happen in equilibrium.

3 - Social Enterprise Welfare and New Product Diffusion: Model and Empirical Validation at World Bicycle Relief

Vadim Glinsky, Kellogg School of Management, Evanston, IL, United States, vadim.glinskiy@kellogg.northwestern.edu, Jan A. Van Mieghem

We present a dynamic model of a social enterprise (SE) that offers a product through its not-for-profit and for-profit channels. Product offered in either channel stimulates future market (for-profit) demand. We present a continuous-time, 2 channel product diffusion model and a closed-form expression for the optimal production policy. We perform sensitivity analysis on two conflicting objectives: maximize social welfare or profitability. Our theoretical results are validated with a rigorous empirical study of World Bicycle Relief. We find conditions for which the for-profit channel can increase social welfare and the not-for-profit channel can increase profitability.

4 - The Perils of Personalized Pricing with Network Effects

Jeffrey Shulman, University of Washington, Seattle, WA, 98195-3226, United States, Amin Sayedi, Bita Hajehashemi

Given technological advances, a growing number of companies charge different prices to different customers based on their anticipated willingness to pay. This paper uses an analytical model to examine the impact of personalized pricing in markets for which there exist positive network effects. Video games are an example of a product with positive network effects. There's value to playing the game alone, but this value increases when playing with another person who owns the game. Rather than amplify benefits of personalized pricing, network effects can actually cause personalized pricing to diminish firm profitability and produce counterintuitive findings about prices and consumer surplus.

■ SA26

CC- Room 4C-1

Research in E-commerce Platform

General Session

Chair: Hyun Seok (Huck) Lee, College of Business, Oregon State University, Corvallis, OR, 97330, United States

Co-Chair: Junghee Lee, Tulane University, New Orleans, LA, 70118, United States

1 - Disclosing Product Availability in Online Retail

Eduard Calvo, IESE Business School, Barcelona, Spain, ecalvo@iese.edu, Laura Wagner, Ruomeng Cui

Online retailers disclose product availability to influence customer decisions, as a form of pressure selling designed to compel customers to rush into a purchase. Can the revelation of this information drive sales and profitability? We study the effect of disclosing product availability on product sales and returns. We find that the disclosure of scarcity signals causally increases sales by13.6% but product return rates increase by 17.0%. Net sales increase by 12.5%. In addition, we propose a data-driven, machine learning algorithm that exploits these results by prescribing the timing of disclosure of scarcity signals in order to boost sales without spiking returns.

2 - Unpacking E-retail Platform Owner Intervention in Order Fulfillment

Hyun Seok (Huck) Lee, College of Business, Oregon State University, Corvallis, OR, 97330, United States, HyunSeok.Lee@oregonstate.edu, Yusoon Kim, Junbo Son

Large e-commerce marketplaces increasingly bring order fulfillment function in-house, resulting in the two internally competing order fulfillment channels – conventional fulfillment by merchant (FBM) and emergent fulfillment by platform (FBP). Using transactions and logistics data in the e-commerce setting, we examine whether the FBP system has a positive intervention effect on order fulfillment performance. We further decompose the entire fulfillment process into three sub-processes (pre-delivery, main delivery, and last-mile delivery) and investigate whether the intervention effect is differential across three sub-processes.

3 - Online-to-offline Platform Models

Joseph Jiaqi Xu, Carnegie Mellon University, Tepper School of Business, Pittsburgh, PA, 15213, United States, jiaqixu@andrew.cmu.edu, Hui Li, Sridhar R. Tayur

We study commonly observed business models for online-to-offline (O2O) platforms. We derive optimal strategies and equilibrium outcomes to understand: how the models function, how best to avoid incentive misalignment and system loss, which model is better for the platform, the merchant, the system, and under what market conditions.

4 - Observed Choices and Unobserved Talents in Online Labor Markets

Jiding Zhang, The Wharton School, Jon M. Huntsman Hall, Philadelphia, PA, 19104, United States, jiding@wharton.upenn.edu, Elena Belavina, Karan Girotra, Kenneth Moon

Our work shows the significance of relationships and flexibility in online labor markets.

■ SA27

CC- Room 4C-2

Supply Chain, Shipping and Transportation

Contributed Session

Chair: Nastaran Khalili, Virginia Tech

1 - Factors Associated with Truck Dwell Times

Haena Kim, University of Washington, Seattle, WA, United States, haenakim@uw.edu

There has been a lack of data to understand the delivery activities that could lengthen truck dwell times; times spent on off-vehicular activities that delivery workers performed while the truck is parked. We focus on analyzing the factors associated with truck dwell times. Ordered logit regression was used as modeling methods in this study. Factors that found to influence the truck dwell time was found to be building type, vehicle type (compact sized, with rolling or swing doors) and type of delivery goods (food, mail, oversized supplies, parcels, office supplies) and number(s) of delivery destination (one or more than one).

2 - Olefin Supply Chain Network Design with Seasonal Feedstock and Uncertain Carbon Tax Rate

Morteza Alizadeh, Graduate Research Assistant, Mississippi State University, Starkville, MS, United States, ma1845@msstate.edu, Junfeng Ma, Mohammad Marufuzzaman, Fei Yu

We propose a three-stage stochastic model for logistics network of producing olefin from biomass. First stage makes facility location decisions. Second stage plans multi-period decisions for feedstock storage, transportation units and olefin production after realizing feedstock seasonality. Third stage finds processing feedstock throughout network by realizing carbon tax uncertainty. Municipal solid waste ensures reliable supply for olefin production. Integrating affinely adjustable robust problem and sample average approximation, a robust approximation method is developed to solve problem. Results by solving real case problem of Mississippi state reveal capability of this model.

3 - A System of Systems Approach to Evaluate the Emergence of Technology on International Regulations for Preventing Collisions at Sea

M.J. Press, George Washington University, Washington, DC, United States

Thirty-seven years ago, the International Maritime Organization (IMO), a specialized agency of the United Nations, adopted nine amendments to the 1972 Convention on the International Regulations for Preventing Collisions at Sea (COLREG). Since 1981, the world has experienced a rapid growth of naval transport technology; however, the international navigational rules remain unchanged. While industry and academic research continue to present technological maritime advances, a statistical examination of simulated data illuminates the inadequacies (increased risk of collision and need for further research) of the current regulations.

4 - Wildfire Catastrophe as a Complex Socio-ecological System Outcome

Farshad Farkhondehmaal, Virginia Polytechnic Institute, Blacksburg, VA, United States, farshad1@vt.edu

The size of wildfires in the Western United States has increased during the last three decades and endangered both society and wildlands while still there is no consensus on the causes of this trend. In the United States, 71499 incidents of wildfire happened just in 2017 which burned over 10 million acres with the estimated cost of $2.9 billion. Different scientists consider varying factors as the main reasons for this trend including climate change and human wildfire ignition. In this paper, I examine the impact of each factor on current wildfire activity. The case study of California wildfires is used for the case study.

5 - Varying Dynamics of False and True News Diffusion under Different Conditions

Nastaran Khalili, Blacksburg, VA, United States, nkhalili@vt.edu

In this paper, I simulate the diffusion of false vs. true news in different conditions. Building on the more generic model of information diffusion which often does not differentiate true vs. false news, I propose “news validation” as a mechanism for individuals seeking validity of a piece of information. I then simulate the model for different levels of sensitivity of society to validation before diffusion. The results demonstrate different modes of information diffusion, beyond what previously are suggested in the literature. The analysis shows explicitly that false news diffusion pattern is different from true ones. The study has significant implications for addressing fake news problems.

■ SA28

CC- Room 4C-3

Model-Based Analysis of the Education System

Sponsored: Service Science

Sponsored Session

Chair: Maryam Andalib, PhD, Ford Motor Company, Dearborn, MI, United States

1 - Policy Modeling for Science Workforce Analysis

Navid Ghaffarzadegan, Virginia Tech, Falls Chruch, VA, 24061, United States, navidg@vt.edu

The US higher education system acts as a very large enterprise with several objectives including production of talented PhD graduates. This outcome, however, turns to the future workforce within the same large enterprise, leading to more outcomes. I use system dynamics modeling to analyze science workforce production and related policies.

2 - Using Simulation Modeling to Examine the Effects of Federal Research Funding on the Academic Science Workforce

Julie A. Maurer, Lead Research Manager, Ohio State University, Columbus, OH, 43210, United States, maurer.99@osu.edu

Past research demonstrates that there are unintended negative outcomes on the academic science workforce when federal higher education research funding fluctuates. This study extends these findings by using hybrid simulation modeling to examine the effects of unstable federal research funding policies on the academic science workforce. Insights into how the workforce structure, federal funding policies and employer preferences interact to influence the career development of academic scientists using ABM and SD modeling techniques will be shared.

3 - University Diversity Performance: A Data Envelopment Analysis Approach

Maryam Andalib, Data Scientist, Ford Motor Company, Dearborn, MI, 48067, United States, maryam.andalib@gmail.com, Konstantinos P. Triantis, Navid Ghaffarzadegan

Despite all the attention and progress to diversify university campuses, many educational institutions are still far from gender and racial parity in their faculty and student populations. An important question is what makes an institution perform better regarding its diversity and the outcomes of under-represented minorities (URM). We construct an institution-level dataset from multiple sources and apply DEA to systematically benchmark, compare, and contrast organizational performance with respect to the educational and work outcomes of URM. We discuss the findings, policy and methodological implications.

4 - A Sentence-based Text Analytic Framework for understanding Voice of the Customer

Sukhwa Hong, Virginia Institue of Technology, Pamplin College of Business, Blacksburg, VA, 24061, United States, sukhwa@vt.edu, Onur Seref, Michelle M.H. Seref

In our study, we propose a sentence-level neural network language model to understand sentence-level elements in which customer satisfaction related information is presented. Our model mimics how human detect customer satisfaction related documents (by finding sentences that contain customer satisfaction related information) for better performance and enhanced interpretability of the model's output.

■ SA29

CC- Room 4C-4

Joint Session AMD/Practice Curated: Applications in Market Design

Sponsored: Auction and Market Design

Sponsored Session

Chair: Robert Day, University of Connecticut, Storrs, CT, 06269-1041, United States

1 - Algorithm Bias - The Case of Medical Resident Matching

Srinivasa Kartikeya Puranam, LaSalle University, Philadelphia, PA, 19141, United States, Michael N. katehakis, Briance Mascarenhas

Artificial Intelligence is a major technical innovation transforming the world, but ethical and bias concerns are emerging about the use of algorithms. This study of the national resident matching program (NRMP) provides insights into its algorithmic biases. We present analytical and numerical evidence.

2 - Using Machine Learning for Modeling Human Behavior and Analyzing Friction in Generalized Second Price Auctions

Karthik Kannan, Purdue University, West Lafayette, IN, 47906, United States, Vandith Pamuru, Yaroslav Rosokha

Recent advances in technology have reduced frictions in various markets. In this research, we specifically investigate the role of frictions in determiningthe efficiency and bidding behavior in a Generalized Second Price Auction (GSP) — the most preferred mechanism for sponsored search advertisements. First, we simulate computational agents in the GSP auction setting and obtain predictions for the metrics of interest. Second, we test these predictions by conducting a human subject experiment. We find that, contrary to the theoretical prediction, the lower valued advertisers (who do not win the auction) substantially overbid. Moreover, we find that the presence of market frictions moderates this phenomenon and results in higher allocative efficiency. These results have implications for policymakers and auction platform managers in designing incentives for more efficient auctions. Finally, after establishing the validity of our computational model, we simulate counterfactuals that provide additional insights into the role that frictions play in the markets that are not feasible (or practical) to investigate with human-subject experiments.

3 - " Now or Later?": When to Deploy Qualification Screening in Open-bid Auction for Re-sourcing

Wen Zhang, University of Texas at Dallas, Richardson, Texas, Richardson, TX, 75080, United States, Wen.Zhang4@utdallas.edu, Qi Chen, Elena Katok

We consider a re-sourcing setting in which a qualified supplier and multiple unqualified suppliers (entrants) compete in an open-bid auction. Conventionally, the buyer screens entrants before the auction (prequalification). We explore an alternative that the buyer postpones the screenings after the auction (post qualification). By characterizing the dynamic structure of the suppliers' equilibrium strategy, we can calculate the buyer's expected cost under post qualification, which is computationally impossible without this characterization. Our comprehensive numerical study shows that post qualification can save cost significantly. We also identify the most beneficial scenarios.

4 - Multiple Vickrey Auctions for Sustainable Electric Vehicle Charging

Konstantina Valogianni, IE Business School, Madrid, Spain, Alok Gupta, Wolfgang Ketter, Soumya Sen, Eric Van Heck

We propose an auction mechanism to optimally schedule EV charging in a sustainable way so that the grid is not overloaded. Our solution has lower computational complexity, compared to state-of-the-art mechanisms, making it easily applicable to practice. Our mechanism creates electricity peak demand reduction and provides optimized charging speed design recommendations. We prove the optimal conditions that must hold, so that different stakeholder objectives are satisfied. We validate our mechanism on real-world data and examine how different trade-offs affect social welfare and revenues, providing a holistic view to grid stakeholders that must satisfy potentially conflicting objectives.

5 - Expansion and Seller Competition in Online Marketplaces

Wenchang Zhang, PhD Student, University of Maryland, College Park, MD, 20904, United States, zhangwenchang89@gmail.com, Wedad Jasmine Elmaghraby, Ashish Kabra

Market expansion is one of the key elements to the success of an online platform, especially for platform startups. Using a proprietary dataset from a leading B2B liquidation platform, we estimate that the supply-side market shocks have a significant positive effect in accelerating the market growth by substantially incentivizing incumbent sellers to increase their listings. We further show that incumbents adopt such listing expansion strategy in response to the increased competition.

■ SA29a

CC- Room 400

Health Care, Modeling and Optimization III

Contributed Session

Chair: Mehmet Aydemir, CMU, Pittsburgh, PA, 15217, United States

1 - A New Medical Staff Allocation via Simulation Optimization for an Emergency Department in Hong Kong

Wenjie Chen, City University of Hong Kong, Hong Kong SAR, Hong Kong, wenjichen8-c@my.cityu.edu.hk

Whether triage targets can be achieved has been an imperative assessment of service qualities for an emergency department. We focus on triage targets and try to fully meet the target of fast emergency response for critical patient's subject to triage requirements for other category patients by optimizing the medical staff allocation. We develop a discrete-event simulation model and propose a simulated-annealing-based algorithm called ConSA that adopts a special searching mechanism and an efficient simulation budget allocation rule to find a high-quality configuration of medical staff.

2 - Applications of Difference-in-difference Design in Emergency Medicine

Ai Ren, University of Maryland-College Park, College Park, MD, United States, renai@rhsmith.umd.edu, Bruce L. Golden, Edward Andrew Wasil

Difference-in-difference (DID) is a popular and important economics model for estimating causal effects. By reviewing DID-related articles published in top emergency medicine journals since 1990, our survey reports the application of DID models in this domain. Our results indicate that, since 2011, the DID model has been gaining traction and becoming more recognized by top emergency medicine journals.

3 - Data Mining of Hospital Alerts in Emergency Department in Maryland

Xu Zhang, University of Maryland, College Park, MD, United States, Sean Barnes, Bruce L. Golden, Paul Smith

Understanding the underlying connection between emergency rooms can better support decision-making for both patients and hospitals. County/Hospital Alert Tracking System provides real-time and historical information for alerts to describe utilization for hospital emergency room at Maryland. We propose two-steps clustering methods for 21 hospitals in Region III, make comparisons for behavior of alerts between alerts, and evaluate potential time factors that may associate with alerts in clusters. Then we suggest two ways to find cascading event in Region III, explore patterns for such event, and how hospitals are connected.

4 - Enhancing Emergency Department Patient Flow by Increasing the Efficiency of Physician-related Processes by Use of Discrete-event Simulation

Lien Vanbrabant, Hasselt University, Hasselt, Belgium, lien.vanbrabant@uhasselt.be, Kris Braekers, Katrien Ramaekers

Emergency departments (EDs) are continuously exploring opportunities to increase their operational efficiency. Physicians are a major bottleneck and strongly impact ED patient flow, as they have multiple consultations with each patient. Moreover, physicians are a costly resource, resulting in multiple patients being assigned to a single physician simultaneously to make optimal use of their capacity. By use of discrete-event simulation, multiple ways to improve the efficiency of physician-related processes in EDs can be investigated, such as applying appropriate queueing disciplines or limiting physician multitasking.

5 - Stochastic Models for Inpatient Discharge Planning

Mark Alan Lawley, Texas A&M University, College Station, TX, 77843-3131, United States, Maryam Khatami

Delay in discharging inpatients deteriorates patient satisfaction, increases hospital costs, and results in overcrowded units such as emergency department. The inpatient discharge planning problem requires the efficient assignment and sequencing of ready-for-discharge (RFD) patients to resources. Some RFD patients are discharged to home, and some are transferred to rehabilitation centers (RCs). Bed unavailability in RCs could result in inpatient boarding. Taking these bed availability times into account, we model and solve the inpatient discharge planning problem as a two-stage stochastic program with uncertain inpatient discharge processing time and bed request time.

6 - Incorporation of Ride-sharing Platforms into Emergency Medical Services

Mehmet Aydemir, Carnegie Mellon University, Pittsburgh, PA, United States, maydemir@andrew.cmu.edu, Jacquillat Alexandre

In this study, we aim to incorporate services offered by ride-sharing platforms into emergency medical services (EMS). These services can complement the EMS for high-priority patients while it can substitute it for the low priority cases. By doing so, the scarce resources of the EMS can be utilized for more severe patients and hence lead to saving of lives. We model this problem with approximate dynamic programming and calibrate it using real data.

■ SA30

CC- Room 6A

Military Maintenance and Logistics

Sponsored: Military and Security

Sponsored Session

Chair: Javier Salmeron, Naval Postgraduate School, Monterey, CA, 93943, United States

1 - Analyzing Recurrent Events of Aircraft Using Survival Analysis

Seong-Jong Joo, Associate Professor, Air Force Institute of Technology, Wright-Patterson AFB, OH, United States, sludoc95@gmail.com, Gawon Yun

Although there are various applications of survival analysis on recurrent events in the medical field, it is not easy to find those in other areas. We choose aircraft and analyze their recurrent failures using survival analysis. We apply Kaplan-Meier estimators and Cox proportional-hazards models to the failure records of the aircraft, which include categorical and time-varying covariates. We found that mission types and flight hours were significant for explaining the failures of the aircraft.

2 - Simulation-optimization for Wholesale Inventory Planning at Naval Supply Systems Command

Javier Salmeron, Naval Postgraduate School, Monterey, CA, United States, jsalmero@nps.edu, Arnold H. Buss, Emily Craparo, Duncan Robert Ellis, Anton Rowe

The U.S. Naval Supply Systems Command, Weapon Systems Support, manages an inventory of approximately 400,000 maritime and aviation line items valued at over $20 billion. This talk discusses the models developed to plan optimal inventory levels by combining multiple metrics, such as expected fill rate, backorders, safety stock cost, and “churn” (deviation from legacy plan). Most of these metrics require simulation in order to be estimated precisely due to uncertainty in demand and lead time, internal rules for reordering parts, and complex processes for repairable items.

3 - Cyber Physical System Model Implementation and Platform Construction Framework for Defense Industry (in the Missile Manufacturing Process)

Jinbae Kim, Kumoh National Institute of Technology, Gumi, Korea, Republic of, dbk0508@gmail.com

A missile with controller board, such as a guided weapon, produces a controller board through a Surface Mounted Technology (SMT) process. The controller board manufacturing process is composed of automation equipment, and various information related to productivity and quality are generated. In this study, Cyber Physical System (CPS) model is implemented to manage, analyze and control manufacturing process information. We also propose a platform configuration framework for implementing the CPS model. The CPS model proposed in this study and the effects of the platform configuration framework has been proven through actual cases introduced to the Republic of Korea defense industry.

4 - Rethinking Government Supplier Decisions: The Economic Evaluation of Alternatives (EEoA)

James Fan, Assistant Professor, Naval Postgraduate School, Monterey, CA, United States, james.fan@nps.edu, Francois Melese

This paper offers an economic model to assist public procurement officials to rank competing vendors when benefits cannot be monetized. An important defense application is “source selection” - choosing the most cost-effective vendor to supply military equipment, facilities, services or supplies. The problem of ranking public investment alternatives when benefits cannot be monetized has spawned an extensive literature that underpins widely applied decision tools. The “Economic Evaluation of Alternatives” (EEoA) extends the analysis to the supply-side. A unique feature of EEoA is to model vendor decisions in response to government funding projections.

■ SA31

CC- Room 6B

Operations Research Methods in Support of Planning and Analysis

Sponsored: Military and Security

Sponsored Session

Chair: Jonathon Leverenz, Systems Planning and Analysis, Inc, Alexandria, VA, 22302, United States

1 - A Bayesian Perspective on Optimization under Uncertainty

Christopher C. Grubb, Grubb, Fairfax, VA, 22030, United States, chrisgrubb@me.com

Optimization under uncertainty often begins with strategies for mitigating a lack of ‘exact’ knowledge of underlying distributions. This presentation explores Bayesian solution approaches that attempt to characterize the distribution of optimal decisions while accepting uncertainty in the characterization of underlying constraint or cost distributions. More specifically, this presentation covers approaches to optimization under uncertainty, with a focus on comparisons between optimization methods such as robust optimization, chance constraint formulations, distributional robust optimization, and Bayesian decision-making with support from optimization approaches.

2 - Insights on Inventory Management

Stephanie Brown, LMI, Tysons, VA, United States

LMI has developed two models, Peak Policy and NextGen, to address the challenges of managing spare parts when demand is sparse or highly variable and a simulation environment, Financial and Inventory Simulation Model (FINISIM), to test and evaluate any number of inventory policies. This presentation will explore several key insights that have been obtained through this work. For example, simulating transactions with FINISIM highlights the weakness of key assumptions by revealing significant differences between metrics from analytical models and what would likely be attainable in the real world.

3 - Computing Advances in Nuclear Forces

Derek R. Shortt, Systems Planning and Analysis Inc., Alexandria, VA, United States, dshortt@spa.com, Jonathon Leverenz, Christopher C. Grubb, Stephanie Brown

The United States is currently recapitalizing their nuclear weapon systems. There exists legacy computational tools to aid the design and development of nuclear weapons. However, many of these were limited in their ability to understand the design solution space in a comprehensive manner due to limits of computing at the time. Today, computing power is plentiful allowing military operations analysts to combine multiple computational models together to explore the realm of comprehensive solutions while remaining computationally tractable. This presentation covers a tool that explores solutions to nuclear weapon design issues using modern computational tools and techniques.

4 - Force Structure Analysis Optimization and Simulation

Jonathon Leverenz, Systems Planning and Analysis, Inc, Alexandria, VA, 22302, United States, jonathon.leverenz@gmail.com, Roy Shortt, Rivka Howell, Will Garcia, Christopher C. Grubb, Stephanie Brown

Multiple factors influence the ability of a force to meet strategic mission goals. The Force Structure Model (FSM) tool measures the ability and likelihood of meeting mission goals for a given time period while satisfying constraints on asset size, mission areas, operational cycles and other requirements. This presentation discusses the optimization and simulation models used by FSM to create a schedule that maximizes fulfillment of mission goals and to perturb the schedule by disrupting asset availability. The result establishes a probability that the force will be able to fulfill the mission goals and provides a quantifiable prediction of the effective bounds on a force for its intended missions.

■ SA32

CC- Room 6C

Doing Good with Good OR

Emerging Topic: Doing Good with Good OR

Emerging Topic Session

1 - Enhancing the Effectiveness and Efficiency of Food Aid Supply Chains: An Economic Optimization Model for USAID Food for Peace Program's Operations

Weijia Jing, Northeastern University, Boston, MA, 02215, United States

Please check the mobile app for this abstract.

2 - Multiregional Oligopoly with Capacity Constraints

Humoud Alsabah, Columbia University, New York, NY, 10025, United States

Please check the mobile app for this abstract.

3 - Atlanta Police Zone Redesign via Data-Driven Optimization

Shixiang Zhu, Georgia Institute of Technology, Atlanta, GA, United States

With fast population growth, Atlanta's old police zone districting caused inefficient police operations and long response time. Since 2017, we collaborated with Atlanta Police Department to redesign its police zones. We built statistical model to predict police workload and optimized zone districting for workload rebalance. Our proposed plan was approved by Atlanta City Council and implemented in March 2019.

4 - Unifying Agricultural Wholesale Markets to Increase Farmers' Income: Evidence from the Field

Somya Singhvi, MIT, 235 Albany Street, Cambridge, MA, 02139, United States

Online agri-platforms, that attempt to tackle inefficiencies in traditional agricultural markets, have been launched in many developing countries. In this work, we collaborate with one such government platform, UMP, to (i) rigorously evaluate the empirical impact of UMP on farmers' income, and (ii) design and implement an updated auction design for the platform to further benefit farmers.

■ SA33

CC- Room 602

Advances in Convex and Nonconvex Optimization

Sponsored: Optimization/Computational Optimization and Software

Sponsored Session

1 - Global Optimization of Nonconvex Quadratic Programs and Mixed-integer Quadratic Programs

Carlos Nohra, Carnegie Mellon University, Pittsburgh, PA, United States, cnohrakh@andrew.cmu.edu, Arvind Raghunathan, Nick Sahinidis

This work addresses the global optimization of nonconvex quadratic programs and mixed-integer quadratic programs. We derive convex quadratic relaxations by convexifying nonconvex quadratic functions through perturbations of the quadratic matrix. We also introduce novel branching variable selection strategies which can be used in conjunction with these quadratic relaxations. We integrate the proposed techniques into the global optimization solver BARON and demonstrate their benefits by conducting an extensive computational study on a large collection of problems selected from publicly available test sets.

2 - Truss Topology Design Optimization with Guaranteed Kinematic Stability

Ramin Fakhimi, PhD student, Lehigh University, Bethlehem, PA, United States, raf318@lehigh.edu, Mohammad Shahabsafa, Weiming Lei, Sicheng He, Luis Zuluaga, Joaquim R.R.A. Martins, Tamas Terlaky

Kinematic stability of the truss topology design and sizing optimization (TTDSO) problems is a crucial aspect which is often overlooked in the mathematical optimization models. In this work, we propose a novel mathematical optimization model for the discrete TTDSO problem with Euler buckling constraints. Random perturbations of external forces are used to obtain kinematically stable structures. We prove that by considering the perturbed external forces, the resulting structure is kinematically stable with probability one. Furthermore, we show that necessary conditions for kinematic stability can be used to speed up the solution of discrete TTDSO problem.

3 - A Modified Augmented Lagrangian for Solving Generalized Nash Equilibrium Problems

Jong Gwang Kim, Purdue University, West Lafayette, IN, 47906, United States, kim2133@purdue.edu, Andrew Lu Liu

We present a new primal-dual method, based on a novel, modified augmented Lagrangian (MAL), for solving generalized Nash equilibrium problems (GNEP) where each player's feasible action set depends on other players' actions. We reformulate the GNEP as a saddle point computation using the MAL and propose a provably convergent algorithm to compute a saddle-point, which is shown to be equivalent to an equilibrium of the GNEP. Our method leads to a (Jacobi-like) distributed implementation, and it does not require any boundedness assumptions on variables. The effectiveness of the proposed method is verified by numerical experiments on benchmark test problems.

4 - A Distributed Algorithm to Solve Large-scale Convex Quadratically Constrained Quadratic Programs

Run Chen, Purdue University, West Lafayette, IN, 47906, United States, chen885@purdue.edu, Andrew Lu Liu

Convex quadratically constrained quadratic programs (QCQPs) have many application areas, including signal processing, machine learning, and data analysis. The increasing scales of the resulting QCQPs pose more challenges to the traditional interior point method and call for distributed algorithms. We propose a novel, proximal primal-dual decomposition method, which uses the idea of predictor/corrector to lead to parallelization of the algorithm to solve QCQPs without separable structures. Convergence is proven and numerical results show that the algorithm exhibits favorable performance compared to CPLEX (barrier algorithm) when the problem scales become really large.

5 - Binary Reformulations of Positive Multi-linear Programs with Affine Constraints

Fabian Rigterink, University of Newcastle, University Drive, Callaghan, 2308, Australia

We study positive multi-linear programs with affine constraints—a class of problems that arise in game theory settings and involve large integer products. The large integer products induce numerical instabilities. In this talk, we describe exact binary reformulations that bypass the numerical instabilities. To our surprise, the reformulations in some cases are computationally advantageous when compared to much more sophisticated, state-of-the-art algorithms that exploit the problem's structure.

■ SA34

CC- Room 603

Bilevel Optimization

Sponsored: Optimization/Global Optimization

Sponsored Session

Chair: Xueyu Shi, University of Pittsburgh, Pittsburgh, PA, United States

1 - Sequential Shortest Path Interdiction with Incomplete Information and Limited Feedback

Jing Yang, University of Pittsburgh, Pittsburgh, PA, 15232, United States, jiy75@pitt.edu, Juan Sebastian Borrero, Oleg A. Prokopyev, Denis Saure

We study sequential shortest path interdiction, where an interdictor with incomplete knowledge of the network, and an evader traverses a shortest path in the network. The interdictor, who aims at maximizing the evader's cost, observes only the total cost. The interdictor then uses this limited information feedback to refine her knowledge of the network. Focusing on minimizing the number of periods to recover a full information decision, we show that a greedy interdiction policy requires, in the worst case, an exponential number of periods to converge. Moreover, we consider different versions of imperfect randomized feedback that allows establishing polynomial expected convergence bounds.

2 - Designing Networks Resilient to Clique Blockers

Haonan Zhong, University of Massachusetts-Boston, Boston, MA, 02188, United States, Foad Mahdavi Pajouh

The network design resilient to clique blockers problem (denoted as NDRCB) is to find the minimum cost of connecting a set of vertices such that the cost of blocking cliques via vertex removals is not less than a given constant. We addressed the computational complexity of this problem, proposed an integer programming (IP) formulation, and solved the IP by enforcing constraints in a lazy fashion. We also proposed an exact combinatorial branch and bound algorithm to solve this problem.

3 - A Hierarchy of Bounds for Bilevel Mixed 0-1 Programs

Xueyu Shi, University of Pittsburgh, Pittsburgh, PA, United States, Ted K. Ralphs, Oleg A. Prokopyev

We consider general bilevel programs in which the decision variables of the lower-level problem are binary. A sequence of mixed-integer programming formulations are developed to obtain a hierarchy of bounds for the optimal objective function value of the bilevel programs. The proposed bounds are stronger to those provided by single-level relaxations. Computational study is performed to explore the efficiency of our bounds.

4 - Parametric Inequalities in Multistage/Multilevel Optimization

Ted K. Ralphs, Lehigh University, Industrial and Systems Engineering, Bethlehem, PA, 18015, United States, ted@lehigh.edu, Suresh Bolusani, Sahar Tahernejad

In this talk, we'll discuss the theoretical framework underlying solution algorithms based on the generation of so-called parametric valid inequalities for a general class of optimization problems that includes multi-stage and multi-level problems. We describe the theory of such inequalities, present methods for generating them, and describe a generalized branch-and-cut framework that incorporates them.

■ SA35

CC- Room 604

Network Optimization and Approximation Algorithms for Operations

Sponsored: Optimization/Integer and Discrete Optimization

Sponsored Session

Chair: Fatemeh Navidi, University of Michigan, Ann Arbor, MI, 48105, United States

1 - Constrained Assortment Optimization under the Paired Combinatorial Logit Model

Rohan Ghuge, University of Michigan, Ann Arbor, MI, United States, Viswanath Nagarajan

We study the assortment optimization problem under the paired combinatorial logit model. We study uncapacitated, capacitated and space constrained versions of this problem, which are all known to be NP-hard. We design efficient algorithms that compute approximately optimal solutions, using a novel relation to the maximum-directed-cut problem, a fundamental and well-studied optimization problem. We obtain performance guarantees of 87.4%, 50% and ≈ 50% for the uncapacitated, capacitated and space constrained versions respectively. We also study the assortment problem under more general constraints, for which we obtain a performance guarantee of 38.5%.

2 - Leveraging Information in Online Matching

Yam Huo Ow, Northwestern University, Evanston, IL, United States, yamhuo.ow@kellogg.northwestern.edu, Chaithanya Bandi

Online matching platforms require efficient scaling and quick solution times in highly competitive markets. In this work, we design an online algorithm, which is a variant of the 'Balance' algorithm, that allows us to leverage on distributional information on the bidders' behaviors. Using techniques from Robust Optimization and Factor Revealing LP, we model the informational constraints and incorporate uncertainty sets to bound the feasibility set of our algorithm's performance metrics. We also characterize the improvements gained in the competitive ratios using numerical experiments and data from a major online freelancers' platform.

3 - Approximating Max-Cut under Graph Constraints

Viswanath Nagarajan, University of Michigan, Ann Arbor, MI, 48109, United States

We consider the maximum cut and maximum k-cut problems under graph-based constraints. Our approach can handle any constraint specified in monadic second-order logic on graphs of constant treewidth. Examples of such constraints include stable set, connectivity, dominating set and Hamiltonicity. We give a 0.5-approximation algorithm for this class of problems. Our main technique is the use of linear program relaxations from the Sherali-Adams hierarchy.

4 - Optimal Decision Tree Problem with Noisy Outcomes

Fatemeh Navidi, University of Michigan, Ann Arbor, MI, 48105, United States, navidi@umich.edu

A fundamental task in active learning, known as optimal decision tree problem, involves performing a sequence of tests to identify an unknown hypothesis that is drawn from a known distribution. We design approximation algorithms for a generalization of this problem where certain test outcomes are noisy in both adaptive and non-adaptive setting. Unlike previous work in this area, our algorithms provide guarantees that are nearly best-possible and work for a large number of noisy outcomes per test or per hypothesis where the performance degrades smoothly with this number. We evaluate the performance of our algorithms on real-world and synthetic datasets and observe almost optimal solutions.

■ SA36

CC- Room 605

Robust Satisficing under Uncertainty

Sponsored: Optimization/Optimization Under Uncertainty

Sponsored Session

Chair: Melvyn Sim, National University of Singapore, Singapore, 119245, Singapore

1 - Exploiting Hidden Convexity for Optimal Flow Control in Queueing Networks

Gar Goei Loke, National University of Singapore, Singapore, 419440, Singapore, gargoeiloke@gmail.com, Chaithanya Bandi

Optimal flow control in queues is a challenging problem occurring in many contexts, such as cloud computing, healthcare, revenue management. Motivated by emerging techniques in Robust Optimization, we propose a framework, which additionally tracks present waiting time. We show that the dynamics of a traditional queueing system can be equivalently modeled using our approach. Our key contribution is uncovering the hidden convexity in our model, leading to tractable formulations for obtaining performance guarantees on average and quantiles of waiting time, under arbitrary arrival and service distributions. Our policies are near optimal and perform significantly better than present heuristics.

2 - Advance Admission Scheduling via Resource Satisficing

Minglong Zhou, National University of Singapore, Singapore, Melvyn Sim, Shao-Wei Lam

We study the problem of advance scheduling of admission requests in a public hospital, which affects the usage of critical resources such as operating theaters and hospital beds. The difficulty of quantifying overloading costs and the need to mitigate overutilization lead us to propose a resource satisficing framework that renders resource overutilization less likely and diminishes their impact whenever they occur. The risk of resource overutilization is captured by our resource satisficing index, which better mitigates the risks of overutilization. Our approach aims to balance out the overutilization risks and can be solved via a converging sequence of mixed-integer optimization problems.

3 - Robust Data-driven Vehicle Routing with Time Windows

Zhenzhen Zhang, National University of Singapore, Tat Chee Avenue, Kowloon Tong, Singapore, Singapore, Yu Zhang, Andrew Lim, Melvyn Sim

We propose a distributional robust optimization model for the data-driven Vehicle Routing Problem with Time Windows under uncertain travel times. Our model minimizes an innovative decision criterion, Service Fulfillment Risk Index, which accounts for both the late arrival probability and its magnitude, captures the risk and the Wasserstein ambiguity in travel times, and is efficiently evaluable in closed form. To solve the problem, we develop a branch-and-cut algorithm and a variable neighborhood search meta-heuristic. Computational studies show that our SRI outperforms the canonical decision criteria, lateness probability and expected lateness duration.

4 - Repositioning for Vehicle Sharing: A Risk Mitigation Perspective

Qinshen Tang, National University of Singapore, Singapore, 117592, Singapore, oratq@nus.edu.sg, Yu Zhang, Minglong Zhou

We develop a practical model to support repositioning decisions for platforms such as bicycle-sharing systems, free-float car sharing systems. From a risk mitigation perspective, we model the problem as jointly reducing the risk of violating various constraints. Our model is flexible enough to incorporate random demand, uncertain travel destination and duration, and uncertain repositioning duration. In an N period time horizon, we use a rolling horizon heuristic and reformulate the model to a linear program. The implementation of the model on a real data set from Citi Bike and an operational data set from Car2Go shows that our model is computationally efficient and managerially sound.

■ SA37

CC- Room 606

Advance in Theory and Application of Optimization Under Uncertainty I

Sponsored: Optimization/Optimization Under Uncertainty

Sponsored Session

Chair: Ruiwei Jiang, University of Michigan, Ann Arbor, MI, 48109, United States

1 - Chance-Constrained Scheduling of Underground Pumped Hydro Energy Storage in Presence of Model Uncertainties

Kenneth Bruninx, KU Leuven, Celestijnenlaan, Leuven, B3001, Belgium, kenneth.bruninx@kuleuven.be, Jean-François Toubeau

The optimal operation of underground pumped hydro energy storage system (UPHES) is affected by (i) modeling inaccuracies (e.g., the approximation of nonlinear pump/turbine performance curves) and (ii) model uncertainties (e.g., due to limited knowledge the underground cavity's geometry and hydraulic properties). We leverage chance constrained programming to immunize the day-ahead scheduling of an UPHES against both types of uncertainty. Results demonstrate that this approach allows finding a compromise between conservativeness and economic performance, while being computationally efficient.

2 - Bandit Models of Cyber Intrusion

Jefferson Huang, Naval Postgraduate School, Monterey, CA, 93943-5219, United States, jefferson.huang@nps.edu, Roberto Szechtman

We consider multi-armed bandit models for the attack of computer networks, from the point of view of an attacker. At each time step, the attacker may devote effort to one of a subset of nodes on a network. These nodes may correspond to already infected computers from which useful intelligence can be gained, accessible computers that have yet to be infiltrated, or routers through which snippets of intel from multiple computers can be observed. The objective of the attacker is to collect as much useful intelligence as possible. Algorithms and associated performance guarantees are presented for different policies.

3 - Optimal Genetic Screening for Cystic Fibrosis

Hussein El Hajj, Virginia Tech, Blacksburg, VA, 24060, United States, hme35@vt.edu, Douglas R. Bish, Ebru Korular Bish

Cystic fibrosis (CF) is among the most prevalent life-threatening genetic disorders. Early diagnosis improves quality of life and reduces healthcare expenditures. Most CF newborn screening processes start with a bio-marker test; followed by a genetic test, ending with diagnostic testing, which corrects false-positives. On the other hand, a false-negative represents a missed CF diagnosis. An important decision is which variants to include in the screening panel to reduce the false-negative probability under a testing budget. We develop novel stochastic optimization models, and identify key structural properties of optimal panels, and use these properties to develop efficient algorithms.

4 - Optimization of Active Surveillance Strategies for Prostate Cancer: An Application to Non-markov Disease Models

Zheng Zhang, Zhejiang University, Hangzhou, 48109-2117, China, zzhang0409@gmail.com, Brian T. Denton

Problems involving sequential decisions under uncertainty and imperfect information are often formulated as POMDPs that are difficult to solve and require strong assumptions. In contrast, this article presents an alternative approach based on a two-stage stochastic integer program. We study this problem in the context of active surveillance of prostate cancer where the goal is to maximize a cumulative reward function associated with cancer detection, missed detection, and the cost to test patients. The first stage decision variables include the selection of years to test patients in each strategy and assignment of patients to strategies. We conduct a case study based on validated data.

■ SA38

CC- Room 607

Theoretical and Computational Advances in Stochastic IPCO

Sponsored: Optimization/Optimization Under Uncertainty

Sponsored Session

Chair: Yingqiu Zhang, Virginia Tech, Blacksburg, VA, 24060, United States

Co-Chair: Manish Bansal, Virginia Tech., Blacksburg, VA, 24060, United States

1 - Sample Generation for the Stochastic Unit Commitment Problem

Arnab Sur, IIT Bombay, D-1 Joyashree Park, Behala, Kolkata, 700034, India, John R. Birge

Stochastic unit commitment problems involve discrete variables on unit commitments and continuous variables relating to generation. Sample generation is, however, key to making robust decisions. This talk will describe methods for generating such samples that represent underlying relay states and solving the resulting stochastic MIPs.

2 - Topology Control for Load Shed Recovery under Uncertainty

Yingqiu Zhang, Virginia Tech, Blacksburg, VA, 24060, United States, yqzhang7@vt.edu, Manish Bansal, Adolfo Raphael Escobedo

Maintaining an uninterrupted supply of electricity is a fundamental goal of power systems operators. However, due to critical outage events, customer demand or load is at times disconnected or shed temporarily. This work introduces a two-stage stochastic programming model to deal with the uncertain demand of electric power with known probability distribution, and it uses a conditional value-at-risk to measure the risk level of unrecovered load shed. It maximizes load shed recovery in bulk transmission network by switching transmission lines and performing other corrective actions after the topology is modified. The proposed approach can serve as an online/offline contingency analysis tool.

3 - Assessing Solution Quality for Stochastic Unit Commitment with Economic Dispatch Models

Nahal Sakhavand, University of Texas at Arlington, Arlington, TX, United States, Harsha Gangammanavar

Extensive power flow approximations to the nonlinear non-convex nature of the power systems has introduced inaccuracy in the quality of the optimal solution. In this paper, we present a stochastic optimization and simulation-based framework to apply sampling-based techniques to assess the solution quality of power systems. We present a unit commitment with economic dispatch model under renewable energy uncertainty as our case study.

4 - Survey of Software for Mixed-integer Optimization under Uncertainty

David L. Woodruff, University of California-Davis, Graduate School of Management, Davis, CA, 95616, United States, dlwoodruff@ucdavis.edu

We present a brief survey of software for mixed-integer optimization under uncertainty that is currently available for download as open-source or commercially.

■ SA39

CC- Room 608

Community-Based Operations Research I

Sponsored: Public Sector OR

Sponsored Session

Chair: Michael P Johnson, University of Massachusetts-Boston, Boston, MA, 02125-3393, United States

1 - Local Knowledge in Technical Models of Planning and Evaluation: A Case Study

Jason Wright, MS, University of Massachusetts Boston, Boston, MA, 02125-3393, United States, Jason.Wright004@umb.edu

Rural school districts continue to shrink, and district consolidation is still used to address shrinkage despite community opposition and mixed evidence of effectiveness. The prevailing model of planning and evaluation has often emphasized technical knowledge over meaningful inclusion of local knowledge. Two case studies are used to examine the promises, practices, and results of the technical model of evaluation and interrogate the extent to which this model can incorporate and be sensitive to public input.

2 - Urban Planning and Operations Research: A Review and Critique

Tayo Fabusuyi, PhD, University of Michigan, Ann Arbor, MI, 15206, United States, Michael Johnson

While inquiry in Operations Research (OR) modeling of Urban Planning (UP) processes is long-standing, the OR discipline has not influenced UP at a level of other domains such as public policy and information technology. Could an OR approach which focuses on the complex, emergent nature of cities and the institutional environment enable interventions that better address challenges that are complex, multi-stakeholder and stochastic in nature? Based on a critique of research and practice in OR and UP, we argue that a prospective and prescriptive approach to planning that embraces mixed-methods can help researchers and practitioners develop programs that reflect community needs and concerns.

3 - Smart Shrinkage: Better Planning and Decision-making for Legacy Cities

Michael P. Johnson, PhD, University of Massachusetts-Boston, Department of Public Policy & Public Aff, 100 Morrissey Boulevard, Boston, MA, 02125-3393, United States, michael.johnson@umb.edu

Neighborhoods, cities and regions facing long-term declines in population and economic activity may consider alternative responses, such as revitalization, regeneration, shrinkage and abandonment. In this presentation I show that planning decisions intended to improve quality of life, informed by qualitative and quantitative data and analytic methods, implemented through accessible and affordable technologies, and based on notions of social impact and social justice, can enable residents to play a leading role in the positive transformation of shrinking cities and distressed communities.

4 - Understanding Decision-making Strategies to Access Basic Services: A Community Based Study of Slum Dwellers in Small Cities of India

Namesh Killemsetty, MS, University of Massachusetts-Boston, Boston, MA, 02124, United States, namesh.killemsett001@umb.edu

The paper aims to understand the priorities of slum dwellers in small cities of India for better access to housing & basic services. The study intends to document and analyze how slum dwellers structure their problems and, based on these values, identify tradeoffs that may support difficult decisions to enable increased access to stable housing and basic services. The study supports the use of Community Based Operations Research (CBOR) as a framework that accommodates multiple analytical methods such as Strategic Options Development and Analysis (SODA) and Value-Focused Thinking (VFT) to highlight the voices of slum dwellers and identify solutions to optimize their efficiency and social equity.

■ SA40

CC- Room 609

Optimization Algorithms for Learning Models

Sponsored: Optimization/Nonlinear Programming

Sponsored Session

Chair: Dongdong Ge, Shanghai University of Finance and Economics, Shanghai, China

1 - Principal Component Projection and Regression in Nearly Linear Time through Asymmetric SVRG

Yujia Jin, Stanford University, Stanford, CA, United States

Given a data matrix A and a vector v, solving principal component projection (PCP), projecting v onto the top-eigenvalue-space of A, and principal component regression (PCR), solving regression restricted to the top-eigenvalue-space are fundamental problems in machine learning, optimization, and numerical analysis. In this work we provide first algorithms that solve these problems in nearly linear time for sufficiently large data matrices for any fixed eigenvalue gap. We achieve our results by providing a reduction from PCR and PCA to solving asymmetric linear systems which we then solve efficiently through an asymmetric variant of SVRG that we believe is of independent interest.

2 - Optimization Methods for Learning Models: Adaptation, Acceleration, and Subsampling

Bo Jiang, Shanghai University of Finance and Economics, Shanghai, China, jiang.bo@mail.shufe.edu.cn, Xi Chen, Tianyi Lin, Shuzhong Zhang

In this talk we present a suite of algorithms for solving optimization models arising from applications in machine learning and statistics. Typically, the objective in such models may involve a large number of terms, hence subsampling is appealing. In general, popular optimization methods for solving such problems include the high-order tensor approximation approach, which requires the knowledge on some problem parameters. To make such methods practical, one will need to find ways of implementation without such knowledge. We discuss methods that exhibit an accelerated iteration bound while maintaining the traits of being adaptive and allowing subsampling.

3 - New Coordinate Descent Methods for Structured Nonconvex Optimization

Qi Deng, Shanghai University of Finance and Economics, Shanghai, China, qideng@sufe.edu.cn, Chenghao Lan

We study a class of structured nonconvex problems in which the objective function is both nonconvex and nonsmooth. Several new coordinate descent methods are developed for solving such problems in the large-scale setting. For the proposed methods, we prove asymptotic convergence to the critical points and establish sublinear convergence rates for some optimality measures. Empirical studies on sparsity-inducing learning models demonstrate the advantages of our proposed methods.

4 - Interior-point Methods Strike Back: Solving the Wasserstein Barycenter Problem

Zikai Xiong, Fudan University, Shanghai, China, zkxiong16@fudan.edu.cn, Dongdong Ge, Haoyue Wang, Yinyu Ye

Computing the Wasserstein barycenter of a set of probability measures under the optimal transport metric can quickly become prohibitive for traditional second-order algorithms, as the support size of these measures increases. In this paper, we overcome the difficulty by developing a new adapted interior-point method that fully exploits the problem's special matrix structure to reduce the iteration complexity and speed up the Newton procedure. Different from existing regularization approaches, our method achieves a well-balanced tradeoff between accuracy and speed. A numerical comparison with emerging algorithms exhibits its computational advantages and practical effectiveness.

■ SA41

CC- Room 610

Optimization in Clustering and Dense Submatrix Localization

Sponsored: Optimization/Linear and Conic Optimization

Sponsored Session

Chair: Brendan Peter William Ames, University of Alabama, Tuscaloosa, AL, 35406, United States

1 - Exact Semidefinite Clustering under the Heterogeneous Planted Cluster Model

Brendan Peter William Ames, University of Alabama, Tuscaloosa, AL, 35406, United States, Aleksis Pirinen

Clustering, the sorting of data into groups of similar items, is a fundamental task in machine learning and statistical analysis. Until recently, most computational methods for clustering relied on heuristics with no theoretical guarantee ensuring that clusters would be correctly identified. I will present recent results partially addressing this issue. Specifically, I will discuss a new probabilistic model for clusterable data, called the heterogeneous planted cluster model, and establish conditions on the parameters in this model that ensure that the underlying clusters can be recovered using the solution of a particular semidefinite program.

2 - Convex Optimization for Dense Submatrix Discovery

Polina Bombina, University of Alabama, Tuscaloosa, AL, United States, Brendan Ames

We consider the problem of identifying the densest mn-submatrix in a given binary matrix. We propose a new convex relaxation for this problem. Further, we propose a first-order method for solving this relaxation based on the alternating direction method of multipliers and empirically confirm our predicted recovery thresholds using simulations involving randomly generated graphs, as well as social and collaborative networks.

3 - Data-dependent Distances for Unsupervised Learning

James Murphy, Tufts University, Medford, MA, United States, jm.murphy@tufts.edu, Anna Little, Mauro Maggioni

Approaches to unsupervised clustering with data-dependent distances are proposed. By considering metrics derived from data-driven graphs, robustness to noise and cluster geometry is achieved. The proposed algorithms enjoy theoretical guarantees on flexible data models, and also have quasilinear computational complexity in the number of data points. Applications to a range of real data will be shown, demonstrating the practical applicability of our methods.

4 - Universality of Computational Lower Bounds for Submatrix Detection

Matthew Brennan, Massachusetts Institute of Technology, Cambridge, MA, United States, Guy Bresler, Wasim Huleihel

In submatrix detection, the task is to detect a k by k submatrix with entries sampled from a distribution P in an n by n matrix of samples from Q. This generalizes well-studied problems such as biclustering and community detection. These problems seem to exhibit a universal phenomenon: there is a statistical-computational gap depending on P and Q between the minimum k at which this task can be solved and at which it can be solved efficiently. We characterize this gap as a tradeoff between k and the KL divergence between P and Q through average-case reductions, for a wide class of pairs (P, Q).

■ SA42

CC- Room 611

Network Optimization Models for Evacuation, Resilience, and Infrastructure Restoration

Contributed Session

Chair: Shwetank Sharan, Indian Institute of Technology-Kharagpur, LBS Hall, Kharagpur, 721302, India

1 - A Mixed Integer Linear Programming Model for Road

Sachin Mhatre, Research Assistant, North Carolina Agricultural & Technical State University, Greensboro, NC, United States, shmhatre@aggies.ncat.edu

Natural disasters always have an upsetting effect on infrastructure and human life in many ways. The effective restoration of the damaged road network of the affected areas minimizes the number of casualties and delay in relief operations. In this study, a MILP model is developed to address a short-term road restoration problem to maximize the accessibility to the critical locations within the first three days of a disaster strike. The model identifies critical roads to be restored to reconnect the network and allocates the resources to repair those roads. The model aids decision making during the response stage of the disaster, which will improve the disaster making in disaster management.

2 - Stochastic Optimal Control Model for Evacuation Planning under Capacity Uncertainty

Hyeong Suk Na, Pennsylvania State University, University Park, PA, United States, hxn144@psu.edu, S. Ilgin Guler, Necdet Serhat Aybat, Soundar Kumara

The emergency management agencies are faced with numerous challenges during the evacuation due to several unpredictable traffic conditions. This study addresses uncertainties of the road capacity induced by traffic congestion in a real evacuation situation. To partially describe the capacity drop phenomenon, we define the new fundamental relation between traffic flow and density. An evacuation network flow model based on the Cell Transmission Model with joint chance constraints is proposed to deal with the uncertainties and the model reliability is investigated. Several numerical case studies are provided to examine the applicability of our models on various evacuation scenarios.

3 - Critical Infrastructure Resilience-based Restoration Optimization under Uncertainty

Basem Alkhaleel, University of Arkansas, Fayetteville, AR, United States, baalkhal@email.uark.edu

In this research, a mixed integer linear program (MILP) network-based flow model is proposed to optimize the resilience of disrupted critical infrastructures (CIs) under uncertainty. The concept of value at risk (VAR) and total expected resilience were used as different objective values for planning comparisons. A scenario analysis approach was used to quantify uncertainty. Different solutions were found to perform better than the expected value (deterministic) case. A case study based on the French RTE power transmission network was provided for testing.

4 - Interdependent Critical Infrastructure Network Expansion for Resilience Optimization

Achara Tiong, Oregon State University, Corvallis, OR, 97330, United States, tionga@oregonstate.edu, Hector Vergara

A resilient system of interconnected critical infrastructure networks is key to reduce vulnerability to disruptions and maintain expected functionality. For interdependent networks, resilience can be evaluated using a framework based on the network configuration design. We propose a mathematical formulation that optimizes resilience through strategically expanding the interdependent network with new facilities. Preliminary results are presented for two interconnected infrastructures.

5 - Assessing Supply Chains in Era of Industry 4.0 Using Attack Graphs

Shwetank Sharan, Indian Institute of Technology, Kharagpur, India, shwetank@iitkgp.ac.in, Manish Agrawal, Akhilesh Kumar

Supply chains are becoming more complicated attributing to rising vulnerabilities. With the advent of IoT, information handling has become easier but adding to the vulnerabilities. In this article, we have modeled the disruptions using a graphical model to assess the resilience of the supply chain. The transition of the state of the system is stochastically modeled as an absorbing state Markov Chain. The probabilistic transitions of the states are governed based on the defined metric which incorporates the effect of vulnerabilities of the sensors involved. The proposed model enables us to assess the risk of the nodes and formulate risk mitigation strategies to improve overall security.

■ SA43

CC- Room 612

Decision Diagrams for Mathematical Programming

Sponsored: Computing

Sponsored Session

Chair: Margarita Castro, University of Toronto, Toronto, ON, Canada

1 - Compact Representation of Near-optimal Integer Programming Solutions

Thiago Serra, Bucknell University, Lewisburg, PA, 02139, United States, John Hooker

We show how all solutions within a given tolerance of the optimal value can be efficiently and compactly represented in a weighted decision diagram. The structure of the diagram facilitates rapid processing of a wide range of queries about the near-optimal solution space, as well as reoptimization after changes in the objective function. We also exploit the paradoxical fact that the diagram can be reduced in size by including additional solutions. We show that a “sound reduction” operation, applied repeatedly, yields the smallest such diagram that is suitable for post optimality analysis, and one that is typically far smaller than a tree that represents the same set of near-optimal solutions.

2 - Solving MINLPs via Decision Diagrams

Danial Davarnia, Iowa State University, Ames, IA, 50010, United States, Willem van Hoeve, Christian Tjandraatmadja

We give an update on the recent developments for Dexter: An algorithmic framework based on Decision Diagrams to solve mixed integer nonlinear programs.

3 - Lifting and Cut-generation Techniques Using Decision Diagrams

Margarita Paz Castro, University of Toronto, Toronto, ON, M5S 3G8, Canada, mpcastro@mie.utoronto.ca, Andre Augusto Cire, Chris Beck

Lifting and cut-generation procedures are critical components for the performance of state-of-the-art integer programming solvers. Recent work has shown that decision diagrams (DDs) provide a basis to efficiently compute and strengthen a variety of cuts in both linear and non-linear problems. This talk reviews the main advances in the area and introduces a new lifting procedure based on DDs for 0-1 integer programs. In particular, our algorithm leverages the DD structure to efficiently find facet-defining constraints under certain conditions.

■ SA44

CC- Room 613

Computational Advances in Routing Problems with Emerging Technologies

Sponsored: Computing

Sponsored Session

Chair: Ahmed Ghoniem, University of Massachusetts, Amherst, MA, 01003, United States

1 - The TSP with Drone: Exact and Heuristic Approaches

Amro El-Adle, University of Massachusetts, Amherst, MA, 01003, United States, Ahmed Ghoniem, Mohamed Haouari

We investigate routing a vehicle and its companion autonomous aerial drone, known as the Traveling Salesman Problem with Drone (TSP-D). We propose an an exact mixed-integer programming approach for this problem., which also serves as a cornerstone for a heuristic methodology. Computational results are discussed.

2 - Asymptotics of Truck and Multiple Robot Routing

Bo Jones, PhD Student, University of Southern California, Los Angeles, CA, United States, bojones@usc.edu, John Gunnar Carlsson

We consider a new method for package delivery employing both a truck and ground or aerial robots. The truck launches one of multiple robots to deliver a package and continues along its route. Later the robot returns to the truck and readies for its next delivery. With hardware already in place, this new routing promises a way to leverage both the range of the truck and the autonomy of the robots in the near future. We perform an asymptotic analysis of the time needed to complete these robot-assisted routes in the Euclidean plane assuming a smooth demand distribution. We can thus characterize how this time scales as we add more and more customer points as well as the improvement to be gained by introducing robots.

3 - The Mothership and Drone Routing Problem with Obstacles

Stefan Poikonen, University of Colorado Denver, Denver, CO, 80202, United States, Bruce L. Golden

The Mothership and Drone Routing Problem contains a larger vehicle (“Mothership”) and a smaller, faster vehicle (“drone”), which work in tandem to service a set of customers. Both vehicles move in Euclidean space. The introduction of obstacles (dry land, shallow water, political boundaries, etc.) may restrict the path of the mothership. We describe applications and present a solution method that contains a discrete initialization followed by a local continuous improvement via sequential second order cone programs.

4 - An Exact Approach for the Electric Vehicle Routing Problem

Hesamoddin Tahami, Old Dominion University, Norfolk, VA, 23508, United States, htahami@odu.edu, Mohamed Haouari, Ghaith Rabadi

We investigate exact approaches for the Capacitated Electric Vehicle Routing Problem. We propose a novel compact formulation as well as an exponential-size one. We solve this latter formulation by branch-and-cut. A peculiar feature of this approach is that it embeds an exact separation algorithm of the so-called rounded capacity inequalities. We report the results of extensive computational experiments which provide evidence that the compact formulation can be easily used for solving medium-sized instances, and that the proposed exact approach can solve some instances with up to 100 nodes while requiring moderate CPU time.

■ SA45

CC- Room 614

Advances in First-Order Methods

Sponsored: Optimization/Nonlinear Programming

Sponsored Session

Chair: Benjamin Grimmer, Cornell University, Ithaca, NY, 14850, United States

Co-Chair: James Renegar, Cornell University, Ithaca, NY, 14850, United States

1 - An Inexact Primal-dual Smoothing Framework for Large-scale Non-bilinear Saddle Point Problems

Renbo Zhao, MIT, Muckley Bldg, Cambridge, MA, 02142, United States, renboz@mit.edu, Le Thi Khanh Hien, William Haskell

We develop an inexact primal-dual first-order smoothing framework to solve non-bilinear saddle point problems with primal strong convexity. Compared with existing methods, our framework significantly improves over the primal oracle complexity, while it has competitive dual oracle complexity. In addition, we consider the situation where the primal-dual coupling term has many component functions. To efficiently handle this situation, we develop a randomized version of our smoothing framework, which allows the primal and dual sub-problems to be solved by randomized algorithms inexactly. We adapt both frameworks for solving convex optimization problems with many functional constraints.

2 - A Unified Framework for Bregman Proximal Methods

David H. Gutman, Texas Tech University, Lubbock, TX, 15232, United States, Javier F. Peña

In this talk we propose a novel framework for the convergence analysis of Bregman proximal methods. This framework enables us to derive the standard O(1/k) rate for the proximal gradient method and new rates for its accelerated variant. The crux of our framework is an upper bound constructed via the convex conjugate of the objective function.

3 - A New Stochastic Optimization Framework for Empirical Risk Minimization

Haihao Lu, Cambridge, MA, 02142, United States

We propose a new stochastic optimization framework for empirical risk minimization. We show that the proposed algorithm is guaranteed to converge at a sublinear, and we prove a generalization bound for the proposed algorithm. Empirically, our proposed method consistently improves the test errors compared with the standard mini-batch SGD in various models.

4 - General Convergence Rates Follow from Rates Assuming Growth Bounds

Benjamin Grimmer, Cornell University, Ithaca, NY, 14850, United States, bdg79@cornell.edu

Often in the analysis of first-order methods, assuming the existence of a quadratic growth bound (a generalization of strong convexity) facilitates much stronger convergence analysis. Hence the analysis is done twice, once for the general case and once for the growth bounded case. We give a meta-theorem for deriving general convergence rates from those assuming a growth bound. Applying this simple but conceptually powerful tool to the proximal point, subgradient, and bundle methods immediately recovers their known convergence rates for general problems from their specialized rates. Future works can assume growth bounds for the sake of analysis without hampering the generality of the results.

■ SA46

CC- Room 615

Joint Session TSL/ITS/Practice Curated: Large-scale Data Analytics for ITS -I

Sponsored: Transportation Science & Logistics/Intelligent Transportation Systems (ITS)

Sponsored Session

Chair: Zhen Qian, Carnegie Mellon University, Pittsburgh, PA, 15213, United States

Co-Chair: Wei Ma, Carnegie Mellon University, Pittsburgh, PA, United States

1 - Driver Strategy and Multi-market Oligopoly: Evidence From New York City

Ruda Zhang, Postdoctoral Fellow, The Statistical and Applied Mathematical Sciences Institute, Durham, NC, 90020, United States, rudazhan@usc.edu

We study the street-hailing industry as a multi-market competition among firms of equal capacity and prove that the game has a Nash equilibrium which is (1) symmetric, (2) essentially unique in that marginal player payoffs are uniform across all invested markets, and (3) globally asymptotically stable under gradient adjustment process and imitative learning. With 868 million trip records of all 13,237 Medallion taxis in New York City from 2009 to 2013, we validate that taxi drivers' behavior conform to this equilibrium under fixed traffic speeds and taxi demand, and drivers learn the equilibrium strategy over time. We also analyze the effect of the launch of an alternative service on the equilibrium.

2 - Learning Traffic as a Graph: Graph Based Neural Networks for Network-scale Traffic Prediction

Zhiyong Cui, University of Washington, Seattle, WA, United States, zhiyongc@uw.edu

Network-wide traffic forecasting is a critical component of modern intelligent transportation systems for urban traffic management and control. With the rise of artificial intelligence, many recent studies attempted to use deep neural networks to enhance prediction performance, given the volume and variety of traffic data has been greatly increased. To capture the complex spatial-temporal dependencies in network-wide traffic data, we learn the traffic network as a graph and propose a graph wavelet gated recurrent (GWGR) neural network. Comparing to baseline models, the proposed model can achieve state-of-the-art prediction performance and training efficiency on two real-world datasets.

3 - Predicting Real-time Surge Pricing of Ride-sourcing Companies

Matthew Battifarano, Carnegie Mellon University, Pittsburgh, PA, United States, mbattifa@andrew.cmu.edu

Ride-sourcing companies such as Uber and Lyft employ surge pricing to balance supply and demand. Surge pricing, if effectively predicted and disseminated, can more efficiently allocate vehicles, save users money and time, and provide profitable insight to drivers, ultimately improving the efficiency and reliability of transportation networks. We propose a general framework to predict the short-term evolution of surge multipliers in real-time using a log-linear model with L1 regularization, coupled with pattern clustering. The model is able to predict Uber surge multipliers in Pittsburgh up to two hours in advance, out-performing naive and non-linear methods across several locations.

4 - A Data-driven Approach for Managing Queues at Signalized Intersections

Liang Zhang, University of Arizona, Tuscon, AZ, United States, liangzhang@email.arizona.edu

We propose a data-driven approach that manages queues at signalized intersections. Instead of using conventional data sources (e.g. roadside traffic surveillance systems), vehicle-based positioning and speed data are utilized to generate flow and queue information used in our approach. The performance of this approach is assessed via the VISSIM platform.

■ SA47

CC- Room 616

Transportation, Operations I

Contributed Session

Chair: Yineng Wang, Tsinghua University, Li Zhaoji Building, Beijing, China

1 - Exact Solution Approaches to Robust Competitive Hub Location Problem

Richa Tiwari, IIM Ahmedabad, Ahmedabad, India, richat@iima.ac.in

In this paper, we study the hub location problem in the presence of competition caused by the presence of already existing airlines in the network. For this, we model the market share captured by the entrant airline as a proportional gravity-based attraction function. But in real life situations, there exists uncertainty around customer demand which may effect the optimal solution to the problem. To overcome this shortcoming, we model demand uncertainty using an ellipse, a box, an interval and specific budget. This leads to a mixed integer second order conic program, for which we propose several customized exact methods.

2 - Vehicle Scheduling under Stochastic Trip Times: An Approximate Dynamic Programming Approach

Jie Yang, Tsinghua University, Beijing, China, yangjie17@mails.tsinghua.edu.cn

With the full consideration of delay propagation effects, this paper intends to formulate the stochastic dynamic vehicle scheduling problem, which dynamically schedules an urban bus fleet to tackle the trip time stochasticity, reduce the delay and minimize the total costs of a transit system. To address the challenge of "curse of dimensionality", we adopt an approximate dynamic programming approach (ADP) where the value function is approximated through a three-layer feed-forward neural network so that we are capable of stepping forward to make decisions and solving the Bellman's equation through sequentially solving multiple mixed integer linear programs.

3 - Choosing the Optimal Battery Swapping Stations in Smart e-bus System Based on the Location Routing Problem

Joon Moon, Korea University, Seoul, Korea, Republic of, nrbam123@korea.ac.kr, Taesu Cheong, SangHwa Song

When managing public electric vehicles like e-bus, the major problem is the infrastructure of charging stations that can charge electricity. In other words, the deployment of a network of recharging stations is essential due to their limited travel range. This paper considers the problem of choosing battery swapping stations among bus stops for electric vehicles on a traffic network with flow-based demand, based on the location routing problem. We suggest three different mathematical programming models to address this problem and evaluate each model.

4 - Strategic Location Problem for Synchronized Last-mile Delivery with Relaying Drones

Kangbok Lee, POSTECH, Pohang, Korea, Republic of, kangbok.lee3@gmail.com, Kyungduk Moon, Seokwon Kim, Sunil Chopra

This study suggests a two-echelon last-mile delivery system in which packages are relayed from a truck to drones sequentially through docking stations. Following JIT principle, arrivals and departures of the two fleets are to be synchronized at each station by locating stations and allocating demands. To synchronize the operation, a location problem is formulated under continuous demand. Based on the analysis of the mathematical model, key factors of a decision are discovered. Strategic method and algorithmic method are developed to find a solution. After the decision on location is made, the operation problem for the vehicles' schedule with realized demands is modeled and solved for validation.

5 - A Dynamic Deployment Strategy of Public Electric Vehicles' Charging Infrastructures with Demand Uncertainties

Cheng Zhu, Assistant Professor, Texas State University, San Marcos, TX, H2L 0B7, United States, cheng.zhu@mail.mcgill.ca, Ting Wu

Our goal of this data-driven study is to design a dynamic deployment strategy of establishing public EV infrastructure over a medium-term horizon. We first build an Erlang-B queueing model with non-homogeneous arrival rates to gauge random EV demands in a certain region using historical traffic flows. This approach ensures the dynamic update of the EV demands throughout the study horizon. Then we depict the uncertainty set of EV demands and establish a dynamic robust optimization model to solve the deployment-optimization problems, namely, location, quantity and pricing of all types of charging facilities, based on the up-to-date information on costs and technology of EV charging infrastructure.

6 - Online Operation Strategies for Multi-storey Parking Facility

Yineng Wang, LEAD group, Tsinghua University, Beijing, China, ludengxiadeyhc@sohu.com

In response to the situation where there is heavy regular demand in the city center, an online optimization model with two tiers has been promoted to provide advice on the operation policy of the automated multi-storey parking facility and reduce customers' waiting time. The distribution tier leverages on the regularity of parking demand and optimally distributes the parking spots with reinforcement learning, whereas the execution tier plans the operations of elevator with a network model. We have conducted tests based on several possible demand sequences, and the proposed model has commonly improved the efficiency. Moreover, we have shed light on the preferences of design parameter selection.

■ SA48

CC- Room 617

Joint Session TSL/OPT. Under Uncertainty: ADP/Reinforcement Learning in Vehicle Routing III

Sponsored: Transportation Science & Logistics/Freight Transportation & Logistics

Sponsored Session

Chair: Barrett Thomas, University of Iowa, Iowa City, IA, 52242-1000, United States

1 - An Information Collecting Vehicle Routing Problem: Cleaning Up After the Storm

Warren B. Powell, Princeton University, Dept. of Operations Research and Financial Eng, Princeton, NJ, 08544, United States, powell@princeton.edu, Lina al-Kanj, Daniel Jiang

We consider the problem of fixing the distribution grid following a storm, where we have to manage a utility truck that has to learn where outages have occurred while also fixing the grid. We have to capture observable states (location of the truck, visited regions of the grid), and beliefs about regions we have not visited using inferences derived from lights-out calls. We use a novel form of Monte Carlo tree search as a lookahead policy which uses information relaxation to obtain an optimistic estimate of the value of visiting a node. The policy is asymptotically optimal without requiring that all actions be visited. The logic is demonstrated on an actual distribution grid in New Jersey.

2 - Learning a Storage Policy for E-commerce Warehouses

Adrien Rimélé, Polytechnique Montréal, Montréal, QC, Canada, adrien.rimele@polymtl.ca, Michel Gamache, Michel Gendreau, Philippe Grangier, Louis-Martin Rousseau

We consider an Amazon-type warehouse where a fleet of robots stores and retrieves shelves of objects to fulfill customers' orders. To adapt to a changing demand, one can dynamically modify the storage allocation of a shelf, with the goal of improving overall access time for future uncertain requests. We modelled this problem as a stochastic dynamic model and we propose a solution approach to learn a good storage policy using reinforcement learning on an associated partially observable MDP, with the objective to minimize the average cycle time. Preliminary results suggest a gain of about 11% in average cycle time compared to a more traditional approach from the literature.

3 - Enabling Anticipatory Decision-making for Dynamic Vehicle Routing

Ninja Soeffker, TU Braunschweig, Braunschweig, Germany, Marlin Wolf Ulmer, Dirk C. Mattfeld

We consider a dynamic vehicle routing problem with stochastic customer requests. To make anticipatory decisions about accepting or rejecting new customer requests, we apply value function approximation, an approximate dynamic programming approach. Due to the usually large size of state spaces for such problems, we use an adaptive state space partitioning approach. In this presentation, we also show the impact of state space aggregation and routing choices on the solution quality.

4 - Time Window Sizing for Service Routing

Barrett Thomas, Professor, University of Iowa, Iowa City, IA, 52242-1000, United States, barrett-thomas@uiowa.edu, Marlin Wolf Ulmer, Justin Goodson

Firms serving customers at their homes face the challenge of assigning time windows small enough to respect busy schedules, but large enough to allow for routing flexibility. This task is difficult because firms do not know all of the customers who will need service before the customers are notified what their time window is. For a special case, we derive features of the optimal policy. We use these features to motivate a function of arrival time variance that sets time window widths. We learn the parameters of the function and demonstrate significantly better performance than static policies.

■ SA49

CC- Room 618

Advancement in Last-Mile Urban Delivery

Sponsored: Transportation Science & Logistics/Urban Transportation

Sponsored Session

Chair: Bo Zou, University of Illinois, Chicago, IL, 60607, United States

1 - Optimizing Delivery Guarantees to Maximize Customer Satisfaction and Sales in Same-day Delivery Operations

Hossein Fotouhi, George Mason University, Fairfax, VA, 22033, United States, hfotouhi@gmu.edu, Yutong Liu, Elise Miller-Hooks

A mathematical formulation for a same-day delivery problem is presented. The problem consists of an online retailer/distributor whose objective is to maximize customer satisfaction through offering suitable delivery deadlines to customers while trying to minimize total delivery costs assuming a fleet of occasional drivers.

2 - Modeling Crowdshipping as a New Form of Last-Mile On-Demand Urban Delivery: Multiwave Algorithm with Relocation Strategy

Bo Zou, Associate Professor, University of Illinois at Chicago, 2073 Engineering Research Facility, 842 W. Taylor Street, Chicago, IL, 60607, United States, bzou@uic.edu

Our crowdshipping research concerns a specific type of urban delivery dealing with shipments from spatially distributed pickup locations (e.g., restaurants, and retail, grocery, and drug stores) to spatially distributed customers within a guaranteed delivery time. We present a new multiwave algorithm which enables fast and cost-efficient dynamic assignment of shipments to compatible crowdsourcees. The use of the multiwave algorithm is further combined with a clustering-based scheme to strategically reposition crowdsourcees to better match with current and anticipated future shipping demands.

3 - The Omni-channel Vehicle Routing Problem with Time Windows

Albina Galiullina, PhD Candidate, Eindhoven University of Technology, Eindhoven, Netherlands, a.galiullina@tue.nl, Nevin Mutlu, Joris Kinable, Tom Van Woensel

We consider a Vehicle Routing Problem with two fulfilment options: either pickup point (PUP) delivery or home delivery. The use of PUPs resolves the need for visiting all customers' homes, which decreases transportation costs. However, the routing efficiency comes at a price, as the firm needs to provide discounts for PUP delivery to influence customers to choose this delivery option. We optimize the use of these two fulfilment channels with the objective to minimize the total delivery cost that equals to the sum of routing costs and discounts. The potential impacts of our model and policies are illustrated by numerical experiments.

4 - An Urban Shopping Delivery System with Shared Autonomous Vehicles

Marjan Mosslemi, University of California-Irvine, Irvine, CA, 92617, United States

Motivated by the growth of ride sourcing services and expected advent of autonomous vehicles, this research proposes an optimization model and solution algorithm for a system of shared autonomous vehicles (SAVs) which substitutes all the existing personal daily shopping trips. The SAVs, controlled by a central operator, provide origin-to-destination delivery service to households who expect to receive their orders by the end of the time window of their original shopping activity. The AVs are not assigned to open requests in real-time. All the requests enter the system at the same time (not dynamically or stochastically) based on the existing daily activity schedule of the subscribed households.

■ SA50

CC- Room 619

Design and Planning of Parcel Logistics Centers

Sponsored: Transportation Science & Logistics/Facility Logistics

Sponsored Session

Chair: Benoit Montreuil, Georgia Institute of Technology, Atlanta, GA, 30332-0205, United States

1 - Sort Plan Design for Express Parcel Sortation Systems

Reem Khir, Georgia Institute of Technology, Atlanta, GA, United States, reem.khir@gatech.edu, Alan Erera, Alejandro Toriello

We present a two-phase solution approach for creating sort plans operated by express parcel service providers. A sort plan determines how parcels are routed within a sortation hub by specifying their assignment to sort equipment and generating their sort schedules. The objective is to complete sorting parcels by their cutoff times while maximizing resource utilization and balancing parcel flow within the hub.

2 - Using Augmented Reality in Warehouse Design

Sabahattin Gokhan Ozden, Assistant Professor, Penn State Abington, Abington, PA, 19001, United States, gokhan@psu.edu

Augmented reality (AR) is a live direct or indirect view of a physical, real-world environment whose elements are augmented (or supplemented) by computer-generated sensory input such as sound, video, graphics or GPS data. In this presentation, we will demonstrate how to use augmented reality to test different warehouse aisle structures including non-traditional layouts such as Fishbone by only using a smartphone.

3 - How to Get Advantage of Mixed Shelves Storage Policy to Effectively Integrate Picker Routing and Order Batching Planning in a Warehouse

Seyyed Amir Babak Rasmi, Postdoctoral Research Fellow, National University of Singapore, Singapore, Singapore, isesabr@nus.edu.sg, Yuan Wang, Loo Hay Lee, Ek Peng Chew

Order picking (OP) is a time and cost consuming operation in a warehouse to retrieve the items ordered by customers from its storage locations. In this contribution, we present a method to consolidate picker routing and order batching in a mixed-shelves warehouse. We consider two objective functions: minimizing OP makespan and the number of pickers. We apply a heuristic to get advantage of shared storage strategy such that the probability of aisle congestion decreases. We show that how our approach results in effective solutions for OP systems.

4 - Integrate Autonomous Delivery Vehicle and Parcel Locker into Urban E-grocery Distribution Network

Dan Liu, Florida Atlantic University, Boca Raton, FL, United States, liud@fau.edu

Dan Liu, Chang'an University, Xi'an, China, liud@fau.edu, Evangelos I. Kaisar

Motivated by the adaption of autonomous delivery vehicle, parcel locker in the E-Grocery distribution industry, a two-echelon location-routing problem adopting a mixed fleet (2E-VRP-MVMS) for sustainable E-Grocery delivery is studied. A multi-objective optimization model is developed to capture the characteristics of cost component and environmental impact. The goal of the 2E-VRP-MVMS is to determine the location facilities, to optimize the number of parcels delivered to lower stages and routes at each level, also to reduce costs caused by carbon emissions. This research contributes to the last-mile delivery network design domain by adopting mixed fleets.

■ SA51

CC- Room 620

AAS Best Student Presentation Competition I

Sponsored: Aviation Applications

Sponsored Session

Chair: Heng Chen, University of Nebraska-Lincoln, Lincoln, NE, 68588, United States

1 - Rerouting Aircraft during Space Launches using Adaptive Spatial Discretization

Rachael Tompa, Stanford University, Stanford, CA, 94305, United States

To ensure safety during space launches, the FAA restricts a large column of airspace that aircraft are rerouted around. With the increase of space launches, airlines are often penalized with rerouting expenses. Recent research has focused on making these restrictions smaller and dynamic. The problem has been modeled as a Markov decision process and solved using dynamic programming. A major challenge with this formulation is its computational tractability. This talk uses an adaptive spatial discretization method, to increase computational tractability while providing a finer state space discretization. This scalable method results in less disruption in the airspace while reducing risk.

2 - Capacity and Safety Analysis for a Flow Corridor with Dynamic Wake Separation

Azin Zare Noghabi, George Mason University, Seattle, WA, United States

This research presents a simulation framework to investigate the capacity benefits of employing a proposed dynamic wake separation policy in a single lane flow corridor. A new dynamic wake separation concept is suggested that uses information about actual weight and airspeed of aircraft and meteorological conditions to determine the minimum separation between aircraft, which is updated periodically. To show the safety of flow corridor, a rare event methodology is used to estimate the probability of potential wake encounters for a pair of trailing aircraft in cruise altitudes. This analysis is extended to the flow corridor and demonstrates the safety of flow corridor in terms of wake vortex hazard.

3 - A Spectral Approach Towards Analyzing Air Traffic Network Disruptions

Max Zhaoyu Li, Massachusetts Institute of Technology, Cambridge, MA, 02139, United States

The network structure of the air transportation system causes complex delay dynamics; analysis of system performance requires understanding airport connectivities. We apply Graph Signal Processing to analyze flight delay networks, yielding two novel contributions: (1) We use the total variation (TV) of a graph signal to identify and quantify unexpected distributions of airport delays; and (2) we present a spectral eigendecomposition analysis of airport delay networks. We use 10 years' worth of operational data from major US airports in order to spectrally analyze different delay distributions.

■ SA52

CC- Skagit 1

Revenue Management & Pricing Student Paper Prize I

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Ming Hu, University of Toronto, Rotman School of Management, Toronto, ON, M5S 3E6, Canada

1 - RMP Student Prize Session

Ming Hu, University of Toronto, Rotman School of Management, Toronto, ON, M5S 3E6, Canada

This session will feature the finalists of the INFORMS Revenue Management and Pricing Section inaugural student paper competition.

2 - Dynamic Pricing of Relocating Resources in Large Networks

Chen Chen, Duke University, Durham, NC

Motivated by applications in shared vehicle systems, we study dynamic pricing of resources that relocate over a network of locations.

3 - Shapley Meets Uniform: An Axiomatic Framework for Attribution in Online Advertising

Raghav Singal, Columbia University, New York, NY, 10027, United States

We develop an axiomatic framework for attribution in online advertising.

4 - Matching in Online Marketplaces when Talent is Difficult to Discern

Jiding Zhang, Penn State University, Philadelphia, PA

We study the problem of assigning workers to short-term jobs in online marketplaces, where workers are distinguished in quality by skills and high-bandwidth information.

■ SA53

CC- Skagit 2

Innovations in Demand Management

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Chung-Piaw Teo, National University of Singapore Business School, Singapore, 119245, Singapore

1 - Segmenting Demand at Retail Locations Based on Aggregate Data

Yihui Huang, Tsinghua University, Qinghuayuan Street, Haidian District, Beijing, 100084, China, huangyih15@mails.tsinghua.edu.cn, Chen (Mavis) Wang, Lei Zhao

Expected demand is an important measure for a retailer to decide whether to open a new store at a candidate location. Noticing varied shopping behaviors of different customer types, e.g., from residential or office areas, we propose estimation models to segment demand based on aggregate-level store visits, considering temporal and cyclic shopping patterns. We develop an expectation-maximization (EM) algorithm to learn the model parameters and test its efficacy with simulation and real retailer data.

2 - Promotion Design with Network Effects and Path Dependence

Sheng Bi, National University of Singapore, Singapore, bisheng@u.nus.edu

In monopoly-type promotion, a consumer's choice on a product not only depends on its attributes but also on the product eligibility and historic purchases. In this paper, we investigate how to design promotion product set when network effects and path dependence arise in consumer choice models. We first model the network effects and path dependence using Polya's urn process. Then we study the assortment optimization problem under such effects. Under different settings of Polya's urn model, we show that revenue-ordered promotion set is either optimal or near optimal. Data is provided by a fast food company who runs monopoly-type promotion annually.

3 - Thompson Sampling Algorithms for Gaussian Mean-variance Bandits

Qiuyu Zhu, National University of Singapore, Singapore, qiuyu_zhu@u.nus.edu

The mean-variance risk measure is one of the most widely-used risk measures. In the context of the multi-armed bandits (MAB), existing algorithms are LCB-based algorithms. However, these algorithms have strict and often unrealistic assumptions on the reward distributions. In this paper, we develop two Thompson sampling-style algorithms for mean-variance Gaussian MAB with comprehensive regret analyses. Both theoretical analyses and empirical simulations show that our algorithms are better than LCB algorithm. Inspired by numerical simulations, we also propose a combined Thompson sampling algorithm for mean-variance MAB and empirically show that it uniformly dominates LCB algorithm.

4 - An Approximate Dynamic Programming Approach to Dynamic Matching

Fan You, University of Colorado-Boulder, 995 Regent Drive, Boulder, CO, 80302, United States

We study dynamic matching problems with random arrivals and departures, and the objective is to maximize the total reward over a finite planning horizon. We formulate the problem as a Markov Decision Process and approximate the value function using the linear programming-based approach. We show that the Approximate Linear Programs allow for a compact LP formulation that can be solved efficiently. The ALPs provide both upper bounds on the expected reward and can be used to construct control policies. We test our approach numerically on kidney exchange instances taken from the literature.

■ SA54

CC- Skagit 3

Mechanism/Information Design and Network Games

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Emily A. Meigs, MIT, Cambridge, MA, 02139, United States

Co-Chair: Asuman Ozdaglar, Massachusetts Institute of Technology, Cambridge, MA, 02139, United States

Co-Chair: Kostas Bimpikis, Stanford University, Stanford, CA, 94305, United States

1 - Myopic Equilibria via Expander Graphs in Large Trading Networks

Evan Storms, Stanford University, Stanford, CA, United States, estorms@stanford.edu

We study when myopic behavior constitutes an approximate equilibrium in a decentralized, cumulative offer trading network formation game. We show that when firms' preferences satisfy full substitutability, the formation game implements a stable outcome of the related cooperative game, and so an epsilon-Bayes Nash Equilibrium in myopic strategies exists if and only if there is a stable mechanism which is epsilon-Bayesian incentive compatible. A sufficient condition for the existence of an epsilon-Bayesian incentive compatible stable mechanism is that influence graphs, which track how manipulations propagate through the network, belong to the class of vertex-expander graphs.

2 - Optimal Information Provision in Traffic

Emily Meigs, MIT, Cambridge, MA, United States, emeigs@mit.edu, Francesca Parise, Asu Ozdaglar, Daron Acemoglu

We consider a two-road repeated routing game where the state of one road (i.e. the risky road) may change. We investigate how a central planner should provide information to agents about the current state of the risky road to minimize total travel time. We first characterize the optimal incentive compatible recommendation scheme for two steps. We then extend our analysis to the infinite horizon case under the assumption that the condition of the risky road changes according to a Markov chain. We find that full information is not the best recommendation strategy. Instead the central planner should reward experimentation by sending less agents to the risky road when the condition of that road is favorable.

3 - Capability Accumulation and Conglomeratization in the Information Age

Jun Chen, Assistant Professor of Finance, Renmin University of China, Beijing, China

The past twenty years have witnessed the emergence of internet conglomerates fuelled by acquisitions. We provide a simple theoretical model to shed light on this. Firms can combine their capabilities by merging and also spin-off new firms to partition them. We study the stable industry structures, where there no longer exist any profitable mergers or demergers. Positing that recent changes have caused markets to value new capabilities, particularly those held by internet firms, we show this can explain the conglomeratization of internet firms. Moreover, we find that as markets value more capabilities, there is a sharp phase transition in the potential size of the largest firms at a key threshold.

4 - Learning Through the Grapevine

Suraj Malladi, Stanford Graduate School of Business, Stanford, CA, United States, surajm@stanford.edu

We study whether learning is simply difficult or impossible when first-hand information is relayed through long chains of noisy communication. When noise consists of random mutations and transmission failures, difficulty of information acquisition to learn increases, though information processing can still be simple. However, learning is typically impossible in the presence of even an arbitrarily small fraction of biased agents. This can explain why people become stuck at different priors, even if primary evidence points to one answer. We show that a planner can recover partial learning by limiting the number of message forwards, a policy some messaging platforms are starting to use.

■ SA55

CC- Skagit 4

Pricing and Promotion

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Chung-Piaw Teo, National University of Singapore Business School, Singapore, 119245, Singapore

Co-Chair: Xiaobo Li, Singapore

1 - Bundle Size Pricing

Sun Hailong, National University of Singapore, Singapore

We study the bundle size pricing (BSP) problem where a monopoly sells bundles of products to customers, and the price of each bundle depends only on the size (number of items) of the bundle. We show that the BSP problem can be approximated as a convex optimization problem under a class of representative agent model (RAM), which is based on a particular semidefinite programming formulation for a family of semiparametric choice model, using only the first and second moments of customer valuations. The resulting convex approximation model can be efficiently solved using off-the-shelf solvers. Numerical results show that our approach performs very well compared with state-of-the-art heuristics.

2 - Discrete Choice Models with Different Levels of Utility Uncertainty

Ruxian Wang, Johns Hopkins University, Carey Business School, 5345 Strathmore Ave, Kensington, MD, 20895, United States, ruxian.wang@jhu.edu

In this paper, we relax the restriction on the identical distribution for the random utility parts under discrete choice models. The derived new choice model can allow more flexible substitution pattern and has the potential to describe choice behavior more accurately. We also investigate a variety of operations problems under the new class of choice model.

3 - Large-scale Dynamic Pricing for a Tour Operator

Alper Sen, Bilkent University, Department of Industrial Engineering, Bilkent, Ankara, 06800, Turkey, Savas Dayanik, Bahar Kara, Oya Ekin Karasan

We consider the problem of a tour operator which needs to set the prices of its holiday packages on a daily basis. The company is a large operator in Europe and contracts with airlines and hotels to reserve capacity in advance of a holiday season. Using reservations for the past 8 years, the price-demand relationship is estimated at the travel time, origin, destination, hotel category and package duration level. These estimates are fed into a large-scale optimization model which creates price recommendations based on remaining capacity and time. Recommendations are then customized for specific packages. Initial results show that the model leads to significant improvements in revenue.

4 - A Constant-factor Approximation Algorithm for Dynamic Pricing of Rental Product with Advance Reservation

Chungseung Lee, UT at Dallas, Dallas, TX, 75080, United States

We develop a constant-factor approximation algorithm for a dynamic pricing problem where a firm has a limited inventory of rental product and is equipped with an advance reservation system. Customers pay upfront rental fees and use the product for a certain deterministic period of time. Upon the end of the rental, the product is returned and is available to serve future customers. The firm's objective is to maximize the expected total revenue over a finite selling horizon by dynamically adjusting upfront rental fees. We demonstrate that our approximate policy leads to noticeable revenue improvements over the deterministic and the fixed pricing policies, which are widely used in academia and industry.

■ SA56

CC- Skagit 5

Structural Estimation in Revenue Management & Pricing

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Ioannis Stamatopoulos, University of Texas at Austin, McCombs School of Business, Austin, TX, 78705, United States

1 - Economies of Scope in Reverse Auctions: An Application to Road Salt Procurement

Ioannis Stamatopoulos, University of Texas at Austin, McCombs School of Business, Austin, TX, 78705, United States, yannis.stamos@mccombs.utexas.edu, Diwakar Gupta, Matt Schmitt

We study the supply chain implications of dynamic pricing. Specifically, we estimate how reducing menu costs — the operational burden of adjusting prices — would affect supply chain stability.

2 - Loss Aversion in Managers' Pricing Decision Making at a Fast Fashion Retailer

Anna Saez de Tejada Cuenca, Georgetown University, McDonough School of Business, Washington, DC, 90024, United States, as4594@georgetown.edu, Felipe Caro, Keith Chen

We analyze managers' pricing decision making during the sales season of a fast fashion retailer. We observe empirically that, even when assisted by a DSS that recommends revenue-maximizing prices, they systematically deviate from the optimal prices, in a way that is compatible with a number of behavioral biases: loss aversion, salience of the inventory, time discounting, and status quo. We build a structural model to disentangle their degree of loss aversion from other biases, and compare loss aversion coefficients across managers and across product groups (e.g., fashion vs. basics).

3 - The Consequences of Organic Waste Bans: A Dynamic Supply-Side Model of Grocery Retailers

Robbie E. Sanders, UCSD

Each year, the perishable grocery industry produces substantial waste, resulting in considerable costs to firms and generating harmful greenhouse gas emissions. I study the incentives to produce such waste using a novel data set that matches a large supermarket chain's loyalty-card database, including the time stamp for customer trips, with the firm's product-level information on marginal cost, shelf life (perishability), and daily production-processes. In a descriptive analysis, I first show the firm's production of waste correlates positively with the degree of demand uncertainty and with its market power. This relationship is consistent with the classic newsvendor problem and suggests positive waste levels are an endogenously-determined outcome. I then conduct a structural analysis of the artisanal bread category to assess the supermarket chain's incentives to mitigate waste. Currently, grocery retailers have not yet adopted revenue management (intraday markdowns) due to insufficient scale. A hypothetical policy that reduces the costs of revenue management sufficiently to induce adoption would reduce total planned waste for the chain by 13%. Surprisingly, the incentive to reduce waste varies across the individual stores: in several stores, the firm endogenously increases planned waste, suggesting revenue management alone may be insufficient to curb grocery waste. I then simulate the effects of a ban recently enacted in California. The ban increases firms' waste-disposal-costs by mandating composting. For the supermarket chain, this policy increases the returns to revenue management adoption from 3% to 7% and induces the firm to use intraday markdowns, resulting in a combined waste reduction of 31%, though this result depends on the new disposal cost.

4 - Anticipated Regret in Online Common Value Auctions: Empirical Evidence from Ebay

A. Serdar Simsek, Assistant Professor, The University of Texas at Dallas, Naveen Jindal School of Management, Richardson, TX, 75080, United States, serdar.simsek@utdallas.edu, Meisam Hejazi Nia, Ozalp Ozer

We develop a structural model that accounts for bidders' learning and their anticipation of winner and loser regrets in an auction platform. Using a data set from eBay, we show that bidders anticipate significant levels of winner and loser regret and learn from other bidders' bids during the auction. This learning decreases both winner and loser regret anticipation. We also show how regret varies across auction categories (e.g., stamps versus antiques) as well as how bidder experience impact regret. Finally, shutting down bidder regret via appropriate notification policies can increase eBay's revenue by 8.17%, on average.

■ SA57

CC- Yakima 1

Modeling Healthcare Equity, Access, and Outcomes

Sponsored: Public Sector OR

Sponsored Session

Chair: Andreas Holger Thorsen, Montana State University, Bozeman, MT, 59718-6211, United States

1 - Facility Location: A Cumulative Opportunity Approach

Andreas Holger Thorsen, Assistant Professor of Management, Montana State University, Bozeman, MT, 59718-6211, United States, andreas.thorsen@montana.edu, Ronald McGarvey, Maggie L. Thorsen

This paper is concerned with the intersection of facility-location modeling with the measurement of access to health services and health equity. We develop an approach to evaluate the impact of facility location decisions on the population's accessibility to services. Specifically, we describe an approach called the cumulative opportunities measure that has been widely used for measuring access in the field of transport geography, and we then formulate an optimization model that maximizes the cumulative access score over a geographic region. We contend that this approach is a new and useful way to optimize population's access to services.

2 - Evaluating Management of Chronic Diseases at Community Health Centers

Ronald McGarvey, University of Missouri, Columbia, MO, 65211, United States, mcgarveyr@missouri.edu, Andreas Holger Thorsen, Maggie L. Thorsen

Community health centers (CHCs) are federally funded safety-net organizations that provide comprehensive health services to medically-underserved populations. CHCs provide an organizational structure to address widespread health disparities, including outcomes related to chronic diseases. In this paper, we test the relationships between CHC staffing patterns, efficiency, and quality of chronic disease care (specifically, diabetes and hypertension).

3 - An Optimization Model to Reduce Geographic Disparity in Access to Heart Transplant in the United States

Fatemeh Karami, University of Louisville, Louisville, KY, United States, fatemeh.karami@louisville.edu, Monica Gentili, Sean Barnes, Naoru Koizumi

Heart failure is a growing health problem affecting nearly 6 million in the United States, with approximately 200,000 patients suffering from a progressed to end-stage or Stage D heart disease. Heart transplantation is the definitive therapy for end-stage heart disease patients. However, the geographic disparity in access to heart transplant in the United States is substantial. This research uses a mathematical optimization model to design new geographic boundaries for the heart allocation system to reduce geographic disparity in access to transplant.

4 - Trade-off Between Healthcare Accessibility and Individual Liberty

Fan E, PhD Candidate, McGill University, Montreal, QC, Canada, fan.e@mail.mcgill.ca, Angelos Georghiou, Vedat Verter

Community treatment order (CTO) is a coercive legal measure employed by the psychiatrist to enforce medical treatment on severely ill psychiatric patients. Despite its wide use, decisions surrounding CTOs are made based on individual psychiatrist's experience. Essential questions remain to be answered structurally: Who needs a CTO? When to apply a CTO? And, how to implement a CTO? We aim to find the trade-off between maximizing the healthcare accessibility for all patients while minimizing the coercive effects of CTO on individual patients. To counter limitations on data, we calibrate a robust Markov decision model using evidence from both the literature and our empirical research.

■ SA58

CC- Yakima 2

Optimization-based Approaches to Housing Allocation

Emerging Topic: Policy & Government

Emerging Topic Session

Chair: John Dickerson

1 - Allocating Homelessness Interventions Based on Predicted Outcomes

Sanmay Das, Washington University in St. Louis, Dept. of Computer Science & Eng., Saint Louis, MO, 63130, United States, Amanda Kube, Patrick Fowler

We consider possible improvements to the allocation of homelessness services by optimizing over predicted outcomes (re-entry probabilities) given limited resources. We discuss the importance of counterfactual reasoning in predicting outcomes for different types of households given existing administrative datasets, as well as issues of equity and fairness in allocation.

2 - Optimizing Public Policy for Allocating Homelessness Assistance

Duncan C. McElfresh, University of Maryland, College Park, MD, 20742, United States, dmcelfre@math.umd.edu, Phebe Vayanos, Eric Rice

Allocating scarce housing assistance resources to the homeless raises many logistical and practical challenges. Recent OR- and ML-based allocation policies promise to improve the efficiency of these resources, and raise several new questions: How do we earn the trust of policymakers and social workers? What objective should these policies optimize? How do we ensure a policy does not discriminate (e.g., by race or gender)? We present a broad overview of this topic, and recent work addressing each of these questions. We share our own experience collaborating with a municipal housing authority.

3 - Design of Lotteries and Waitlists for Affordable Housing Allocation

Nick Arnosti, Columbia Business School, 3022 Broadway, New York, NY, 10027, United States, Peng Shi

We study a setting in which dynamically arriving items are assigned to waiting agents, who have heterogeneous values for distinct items and heterogeneous outside options. An ideal match would both target items to agents with the worst outside options, and match them to items for which they have high value. Our first finding is that two common approaches - using independent lotteries for each item and using a waitlist in which agents lose priority when they reject an offer - lead to identical outcomes in equilibrium. Both approaches encourage agents to accept items that are marginal fits. We show that the quality of the match can be improved by using a common lottery for all items.

4 - Algorithmic Fairness in Suicide Prevention Interventions for the Homeless Population

Aida Rahmattalabi, University of Southern California, Los Angeles, CA, 90007, United States, Phebe Vayanos, Anthony Fulginiti, Eric Rice, Bryan Wilder, Amulya Yadav, Milind Tambe

We study the social-network based suicide prevention programs as a robust graph covering problem. Unfortunately, state-of-the-art algorithms tend to discriminate individuals (nodes) based on membership in marginalized groups. To remedy this issue, we propose a novel formulation of the problem with group fairness constraints. We provide a formal study of Price of Group Fairness. Further, we develop a tractable approximation scheme applicable to real world instances. Finally, we demonstrate the effectiveness of our approach on several real-world social networks and we show competitive coverage and a significant improvement in group fairness relative to state-of-the-art methods.

■ SA58a

CC- Chelan 1

8:00-8:45 Automation Anywhere / 8:45-9:30 Processim Labs

Vendor Tutorial

1 - Increasing Operational Efficiency with Automation Anywhere's Digital Workforce Platform

Amitai Jacobsen, Automation Anywhere, San Jose, CA, United States

The Automation Anywhere bot building tutorial is designed to showcase Robotic Process Automation (RPA), Cognitive Automation and Analytics tools that make up Automation Anywhere's Digital Workforce Platform. We will demonstrate the process of building digital workers, or bots, on our platform and within minutes. These bots can collect and analyze data and perform tasks that otherwise would be performed by humans, making processes more efficient, reducing errors and improving operational efficiency. The tutorial will feature Automation Anywhere Enterprise, IQ Bot, and Bot Insight and will show that these tools are not meant exclusively for engineers or IT experts but indeed also for business users. Participants will learn the process of creating bots, automating common processes and will have a chance to familiarize themselves with Automation Anywhere's software solutions.

2 - Learning Reimagined | How to Increase Student Engagement through Introducing Innovation into the Classroom

Javier Chan, Processim Labs, San Jose, Costa Rica

Processim Labs uses the concept of gamification to help business school students put classroom concepts into practice. Our tutorial will walk you through how our operations management simulation is used as well as illustrate the many topics that are covered in the game. Over the course of the presentation, attendees will have the opportunity to play the game for themselves in a fun and dynamic virtual world! Don't forget to bring your smartphone!

■ SA59

CC- Chelan 2

Joint Session QSR/Energy: Data Analytics for Renewable Operations

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Hoon Hwangbo, University of Tennessee-Knoxville, Knoxville, TN, 37996-2315, United States

Co-Chair: Ahmed Aziz Ezzat, Rutgers University

1 - Statistical Comparison of Two Wind Power Curves Using Gaussian Process Regression Framework

Abhinav Prakash, Texas A&M University, College Station, TX, United States, abhinavp@tamu.edu, Rui Tuo, Yu Ding

Wind power curve has a lot of information about the performance of a wind turbine. Wind farm operators are often interested in comparing the power curve of a turbine for two time periods to see if there is any change in turbine performance. In this work, we propose a non parametric method (based on Gaussian process) to model the power curve and detect if there is any change in the underlying functional curve given two noisy datasets. We exploit some properties of Gaussian process to build statistical test for determining the change in function for different confidence levels. We apply our method to some wind turbine datasets and compare our result with existing results in the literature.

2 - Adaptive Gaussian Process for Modeling Conflicting Spatial Correlations of Wind Power Output

Hoon Hwangbo, University of Tennessee, Knoxville, TN, 37996-2315, United States, hhwangb1@utk.edu

Wind power output varies by the locations of turbines, and this variation involves two conflicting spatial effects. The closer the locations, turbines' power outputs are (1) more similar due to the nature of wind but, at the same time, (2) more different in the presence of turbine wake effect. We propose an adaptive Gaussian process method to model the conflicting spatial phenomena while identifying the turbine wake effect that preserves the inverse structure of a general spatial correlation.

3 - Short Term Wind Forecasting Using Statistical Models with a Fully Observable Wind Flow

Perr-Sauer Jordan, National Renewable Energy Laboratory, Golden, CO, United States, jordan.perr-sauer@nrel.gov

Accurate short-term forecasting of wind power production is critical to the effective large-scale integration of wind resources on the autonomous renewable energy grid. This study addresses the upper bound of very short-term forecasting accuracy by introducing a fully known and observable atmospheric state. We consider simulation data at 5-min temporal and 2-km spatial resolution from the National Renewable Energy Laboratory's Wind Integration National Dataset (WIND) Toolkit. As a proof of concept, we pick one geographical point and illustrate the correlation of 5-minute lagged surrounding wind speeds for both easterly and westerly flows.

4 - Uncertainty Quantification for Extreme Quantile Estimation Using Importance Sampling with Stochastic Simulation Model

Qiyun Pan, University of Michigan, Ann Arbor, MI, 48109-2117, United States, Eunshin Byon

The increasing wind turbine size and mass entail serious concerns on the reliability of wind turbines. Accordingly, the international standard requires turbine designers to estimate extreme loads in an effort to ensure reliable operations during a design life. At the design stage, physics-based aeroelastic simulators can be used for this purpose. Due to the large uncertainty in extreme load estimations, importance sampling method has been introduced to reduce the estimation uncertainty. This study aims to quantify extreme load estimation uncertainties by constructing asymptotically valid confidence intervals using importance sampling with stochastic simulation models.

■ SA59a

CC- Chelan 3

Disaster and Emergency Management I

Contributed Session

Chair: Daniel Suarez, Universidad de Los Andes, Bogotá, 111021647, Colombia

1 - Managing Gas Supplies in a Short-notice Hurricane Evacuation

Monir Sabbaghtorkan, University at Buffalo (SUNY), Amherst, NY, United States, monirsab@buffalo.edu, Rajan Batta, Qing He

Gasoline shortages and long lines at the pump spread at stations is not a new issue during large-scale evacuations ahead of hurricanes. One of the reasons for this problem is that evacuees rush to fuel up in a panic. Therefore, they try to get gas as much as they can without considering their true need and without considering other evacuees. This work presents a formulation to assign evacuees to specific gas stations along evacuation routes (based on their initial fuel level) and to restrict the amount of gas each gas station is allowed to give to each client. The objective we seek in this work is to maximize the number of evacuees that successfully reach the safe zone.

2 - Leveraging Social Media Data for Disaster Relief Management

Jonathan D. Lonski, Clemson University, Clemson, SC, United States, jdlonsk@g.clemson.edu, Scott J. Mason, Pamela Murray-Tuite

Recent natural disasters like Hurricane Sandy (2012) and Hurricane Harvey (2017) have left survivors stranded without basic supplies necessary for survival. During such disasters, nonprofit organizations receive donations of supplies, and then must transport them to survivors. While data regarding survivor needs is being collected, decision makers often must allocate donated supplies before all information is available. We investigate supplementing traditional data collection methods with input from social media platforms to improve transportation system planning. We discuss the use of machine learning to analyze Twitter data (tweets) to develop improved survivor demand forecasts.

3 - Bi Objective Bi Level Robust and Possibilistic Humanitarian Logistic Model Considering Social Cost and User Equilibria

Luis Yañez, PhD Candidate, Universidad de Chile, Valparaiso, Chile, luis.yanez@usm.cl, Cristian Cortés, Pablo Rey

In this paper, we propose a bi-objective and bi-level possibilistic robust model for humanitarian logistics, considering social costs of deprivation and user equilibria. In an integrated manner for stages prior to and following the occurrence of a natural disaster, this paper consider decisions like location and allocation of inventories, distribution and routing of vehicles for critical supplies such as drinking water, considering the users equilibria as a decision for a lower level of modeling, where the route choice seeks an equilibrium based on the Wardrop principle.

4 - Incorporating Social Media Information in Search Planning: Application on Gasoline Search During Hurricane Irma

Abhinav Khare, University at Buffalo, Buffalo, NY, United States, abhinavk@buffalo.edu, Rajan Batta, Qing He

Shortages of essential commodities like gasoline & water during the evacuation period of a forecasted disaster gives rise to search problem for the evacuees. Evacuees of Hurricane Irma in Florida drove around searching for gasoline and reported long lines or stations without gasoline. We develop a methodology that infers probabilistic information about ground truth from social media and incorporates it in a search planning model. The model plans the path for searching a target on the nodes of a graph (network connecting gas stations) with an inferred probability of finding target on the node. This method can be generalised for other node search problems with probabilistic information.

5 - A Sampling-based, Math-heuristic Stochastic Programming Approach to Support Risk Management Decisions

Daniel Suarez, Universidad de los Andes, Bogotá, Colombia, de.suarez12@uniandes.edu.co, Natalia Torres, Camilo H. Gomez

Stochastic programming is a compelling tool to address risk management decisions (e.g., mitigation and preparedness investments, and response actions) related to natural disasters. However, exact optimization methods and traditional decomposition techniques (e.g., Benders) face convergence issues when considering integer variables and dealing with the large number of scenarios required to represent hazard variability in risk analysis. We explore sampling-based, as well as math-heuristic strategies, to improve the computational efficiency of stochastic programming for risk management decisions without sacrificing the accuracy in the modeling of hazard-related uncertainties.

■ SA60

CC- Chelan 4

IEEE Transactions on Automation Science and Engineering Invited Session

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Shiyu Zhou, University of Wisconsin-Madison, Madison, WI, 53706-1572, United States

1 - A Generic Health Index Approach for Multisensor Degradation Modeling and Sensor Selection

Minhee Kim, University of Wisconsin–Madison, Madison, WI, United States, mkim555@wisc.edu, Changyue Song, Kaibo Liu

The challenge of multisensor degradation modeling lies in that the sensor signals are often correlated and may contain only partial or even no information on the degradation status of a unit. To address these issues, this study proposes a novel data fusion method which develops a latent linear model to select informative sensors and construct a 1-D health index (HI) from their signals. Compared to the existing literature, the proposed method enjoys several unique advantages including general applicability and high computational efficiency.

2 - A Sequential Bayesian Partitioning Approach for Online Steady State Detection of Multivariate System

Jianguo Wu, Peking University, Beijing, China, j.wu@pku.edu.cn

Steady state detection is critically important in many engineering fields, such as process monitoring and control. In this paper, we propose an efficient online steady state detection method for multivariate systems through a sequential Bayesian partitioning approach. The signal is modeled by a Bayesian piecewise constant mean and covariance model, and a recursive updating method is developed to calculate the posterior distributions analytically. The duration of the current segment is utilized for steady state testing. Insightful guidance is also provided for hyperparameter selection. The effectiveness of the proposed method is demonstrated through thorough numerical and real case studies

3 - Dirichlet Process Gaussian Mixture Models for Real-time Monitoring and Their Application to Chemical Mechanical Planarization

Zhenyu Kong, Virginia Tech, Dept of Industrial and Systems Engineering, Blacksburg, VA, 24061, United States, zkong@vt.edu, Jia Liu

The goal of this work is to use sensor data for online detection and identification of process anomalies (faults). In pursuit of this goal, we propose Dirichlet process Gaussian mixture (DPGM) models. The proposed DPGM models have two novel outcomes: 1) DP-based statistical process control (SPC) chart for anomaly detection and 2) unsupervised recurrent hierarchical DP clustering model for identification of specific process anomalies. The presented DPGM models are validated using numerical simulation studies as well as wireless vibration signals acquired from an experimental semiconductor chemical mechanical planarization (CMP) test bed.

4 - Dynamic Inspection of Latent Variables in State-space Systems

Shuai Huang, University of Washington, Seattle, WA, 98195, United States, shuai.huang.ie@gmail.com, Tianshu Feng, Xiaoning Qian, Kaibo Liu

The state-space models are widely used in a variety of areas where a set of observable variables are used to track some latent variables. It comes to our awareness that an important problem has been largely neglected. In many applications, although the latent variables cannot be routinely acquired, they can be occasionally acquired to enhance the monitoring of the state-space system. In this paper, novel dynamic inspection methods under a general framework of state-space models are developed to identify and inspect the latent variables that are most uncertain.

■ SA61

CC- Chelan 5

Statistical Design for Controlled Experiments in the Big Data Era

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Qiong Zhang, Clemson University, Clemson, SC, 29634, United States

Co-Chair: Lulu Kang, Illinois Institute of Technology, Chicago, IL, United States

1 - Pairwise Sequential Randomization and its Properties

Yichen Qin, Assistant Professor, University of Cincinnati, Cincinnati, OH, United States

In comparative studies, such as in causal inference and clinical trials, balancing important covariates is often one of the most important concerns. However, chance imbalance still exists in many randomized experiments. To address this issue, we introduce a new randomization procedure, called pairwise sequential randomization (PSR). With a large number of covariates or a large number of units, the proposed method shows substantial advantages over the traditional methods in terms of the covariate balance, estimation accuracy, and computational time. Numerical studies and real data analysis provide further evidence of the advantages of the proposed method.

2 - Design for Controlled Experiments for Social Networks with Covariates

Lulu Kang, Associate Professor, Illinois Institute of Technology, Chicago, IL, 60616, United States, lkang2@iit.edu, Qiong Zhang

A/B testing refers to the statistical procedure of conducting an experiment to compare two treatments applied to different testing subjects. The subjects participating in the online A/B testing experiments are users who are connected in social networks. Two connected users are similar in terms of their social behaviors. Hence, it is natural to assume that their reactions to online products and services are related to their network adjacency. We propose to use the conditional auto-regressive model to present the network structure and include the network effects and covariate effects in the estimation and inference of the treatment effect and develop a D-optimal design accordingly.

3 - Heavy User Effect in A/B Testing: Identification and Estimation

Jiannan Lu, Microsoft Corporation, Redmond, WA, United States, jiannl@microsoft.com, Yu Wang, Somit Gupta, Ali Mahmoudzadeh, Sophia Liu

On-line experimentation has become an integral part of software development. To timely incorporate user feedback and continuously improve products, many software companies have adopted the culture of agile deployment, requiring online experiments to be conducted and concluded on limited sets of users for a short period. While conceptually efficient, the result observed during the experiment duration can deviate from what is seen after the feature deployment, which makes the A/B test result highly biased. We provide theoretical analysis as well as empirical evidence to show that the heavy user effect can contribute significantly to it.

4 - A Discrepancy-based Design for A/B Testing Experiments

Yiou Li, Assistant Professor, DePaul University, Chicago, IL, United States, yli139@depaul.edu, Lulu Kang

The aim of this work is to introduce a new design of experiment method for A/B tests in order to achieve an accurate estimate of treatment effect under model uncertainty. We propose a model-free discrepancy-based criterion and show that the design minimizing this criterion significantly improves the accuracy of the treatment effect(s) estimates under model uncertainty. More importantly, the proposed design is applicable to both continuous and categorical response measurements. We develop two efficient algorithms to construct the designs by optimizing the criterion for both offline and online A/B tests.

■ SA62

CC- Tahoma 1

Joint Session HAS/Practice Curated: Healthcare Public Policy

Sponsored: Health Applications

Sponsored Session

Chair: Hui Zhao, The Pennsylvania State University, University Park, PA, 16802, United States

1 - Big Data in Non-profits: Insights from Staffing in Blood Donation

Wilson Lin, University of Southern California, Los Angeles, CA, United States, Susan F. Lu, Tianshu Sun

How can organizations leverage staffing to achieve better outcomes, beyond fulfilling operational needs? In collaboration with a Chinese blood bank, we observe whether and how different nurses may influence donors' donation decisions through interaction on the bloodmobile. Using a unique dataset at the interaction level, we estimate the effect of nurse donor matching on a donor's donation volume and that improved matching can provide economically significant benefits for the blood bank.

2 - Government Ideology and Responses from Hospitals to the Affordable Care Act Legislation

Justin Kistler, University of South Carolina, Columbia, SC, 29212, United States, justin.kistler@grad.moore.sc.edu, Luv Sharma, Donald J. Schepker, Manoj Malhotra

Following the passage of the Patient Protection and Affordable Care Act, hospitals were financially incentivized to improve patient experience, requiring a significant investment of resources. Using real options theory, we argue that subjective assessments of the legislation's future biased firms' valuations of investing in compliance. In particular, we investigate how government ideology influenced perceptions of the legislation's future to affect organizations' decisions to invest in compliance. Results indicate that government ideology has a significant impact on how and when hospitals invest in compliance with the new legislation.

3 - Optimizing Colorectal Cancer Screening Policies Using a Combination of Fecal Immunochemical Test and Colonoscopy

Zhichao Zheng, Singapore Management University, 50 Stamford Road, Lee Kong Chian School of Business, Singapore, 178899, Singapore, danielzheng@smu.edu.sg, Jing Li, Mabel Chou, Ming Dong

Most public guidelines for colorectal cancer (CRC) screening and surveillance recommend two consecutive fecal immunochemical tests (FIT) annually after age 50 and immediate colonoscopy if at least one FIT outcome is positive. The guidelines have not been followed closely in practice and patient compliance is very low. There is still is on-going debate in practice about the values of having FIT before colonoscopy. We propose a partially observable Markov decision process model to optimize the screening policy that combines FIT and colonoscopy and find that FITs can help identify CRC in a timely manner and significantly reduce the number of colonoscopies required when FIT sensitivity is not too low.

4 - Global Drug Diffusion and Innovation with a Patent Pool: The Case of HIV Drug Cocktails

Lucy Xiaolu Wang, Cornell University, Ithaca, NY, United States, xw377@cornell.edu

Designed to reward innovation, patent often leads to high drug prices and then patent infringement. The situation is severe for therapies that require multiple drugs with many patents, notably for HIV. I study the impact of the Medicines Patent Pool that allows generic firms to sublicense drug bundles cheaply for sales in low-income countries. I construct a novel dataset from contracts, procurement, clinical trials, and drug approvals. Using diff-in-diff methods, I find that the pool causes a 7% increase in generic drug supply. In addition, branded-drug makers and others respond to the pool with more clinical trials and drug approvals. Finally, I estimate a structural model to quantify welfare gains.

5 - Inducing Compliance with Post-market Studies for Drugs under FDA's Accelerated Approval Pathway

Hui Zhao, The Pennsylvania State University, Smeal College of Business, University Park, PA, 16802, United States, huz10@psu.edu, Liang Xu, Nicholas C. Petruzzi

To encourage drug innovation, FDA instituted the accelerated drug approval pathway (AP), allowing promising drugs to enter market based on limited evidence with required post-market studies (PMS) to verify drugs' true clinical benefits. However, most PMS are not completed due to incentive issues and challenges FDA faces, including information asymmetry and moral hazard, posing considerable public health risk. We propose an internally consistent and potentially implementable solution through a mechanism design framework. Using data for a real drug, we quantify the value of our solution. Based on interactions with FDA, we also discuss many alternative solutions under different situations.

■ SA63

CC- Tahoma 2

Predictive Analytics & Decision Making in Healthcare

Sponsored: Health Applications

Sponsored Session

Chair: Esmaeil Keyvanshokooh, University of Michigan, Ann Arbor, MI, 48108-1020, United States

Co-Chair: Mark P. Van Oyen, University of Michigan, Ann Arbor, MI, 48109-2117, United States

1 - A Cost-based Analysis for Risk-averse Explore-then-commit Finite-time Bandits

Ali Yekkehkhany, PhD Student, University of Illinois at Urbana-Champaign, Urbana, IL, United States, yekkehk2@illinois.edu, Ebrahim Arian, Rakesh Nagi, Ilan Shomorony

We study an explore-then-commit bandit with finite exploitations. We propose the OTE/FTE-MAB algorithms and obtain an upper bound of order ln(1/e) for the minimum number of explorations that should be done to guarantee the upper bound e for their regret. We further study the case where the cost of arm exploration is not negligible, so a trade-off between cost and regret should be considered. We propose the c-OTE-MAB algorithm that addresses this trade-off by minimizing a linear combination of cost and regret that is called cost-regret function. The c-OTE-MAB cost-regret value approaches the minimum value of the cost-regret function at the rate 1/sqrt(n), where n is the number of each arm exploration.

2 - An Inverse Optimization Approach to Measuring Clinical Pathway Concordance

Yusuf Shalaby, University of Toronto, Toronto, ON, Canada, yusuf.shalaby@mail.utoronto.ca, Timothy Chan, Maria Eberg, Katharina Forster, Claire Holloway, Luciano Ieraci, Nasrin Yousefi

Clinical pathways outline standardized processes in the delivery of care for a specific disease. Disease pathway concordance (DPC) refers to the degree of alignment between the actual care patients receive and the ideal care described in a clinical pathway. It is important to measure DPC so that variations in health system performance and bottlenecks in the delivery of care can be detected, monitored and acted upon. We develop a general methodology for measuring DPC based on inverse optimization, apply our novel concordance metric to a real dataset of colon cancer patients, and show that it has a statistically significant association with survival.

3 - Personalizing Treatment with Non-stationary Bandits

Yonatan Mintz, Georgia Tech, Atlanta, GA, 30308, United States, Anil Aswani, Philip Kaminsky, Elena Flowers, Yoshimi Fukuoka

Due to their busy lives many individuals have a hard time adhering to daily exercise programs. In this talk, we address this problem by leveraging the data and infrastructure of mobile fitness tracking devices to personalize exercise programs for participating individuals. We develop and analyze a new multi-armed bandit model, which we call the ROGUE multi-armed bandit, to adaptively learn each participant's exercise preferences and personalize their exercise programs to increase adherence. We present both computational and theoretical results that show the efficacy of this modeling approach when compared to existing precision fitness approaches.

4 - Personalized Hospital Admission Control: A Contextual Learning Approach

Mohammad Zhalechian, University of Michigan, Ann Arbor, MI, 48109-2117, United States, mzhale@umich.edu, Esmaeil Keyvanshokooh, Cong Shi, Mark P. Van Oyen

We study hospital admission control to select the initial care unit (ICU, SDU, or General) to reduce readmission risks, which are highly heterogeneous due to patient differences. We provide an online contextual learning algorithm, called PAC, which continually learns to make the best personalized care unit assignment under the presence of dynamic capacity constraints. We provide a rigorous performance guarantee for our algorithm. A case study is conducted and the performance of PAC is compared with several alternatives using hospital data.

5 - Dynamic Online Learning and Optimization of Personalized Patient Progression in Chronic Diseases

Esmaeil Keyvanshokooh, University of Michigan-Ann Arbor, Ann Arbor, MI, 48108-1020, United States, keyvan@umich.edu, Mark P. Van Oyen, Mariel Sofia Lavieri, Joshua Stein

We develop new online learning and optimization algorithms for learning personalized patient progression in chronic diseases to alert clinicians and patients. Our Thompson sampling-based approach can handle large sets of covariates and we are able to incorporate the dynamic nature of disease progression. We identify the progression of Glaucoma.

■ SA64

CC- Tahoma 3

Models and Data in Healthcare Analytics

Sponsored: Health Applications

Sponsored Session

Chair: Joel Goh, NUS Business School, Singapore, 119245, Singapore

1 - Deployment Guidelines for Community Health Workers in Sub-saharan Africa

Jonas Oddur Jonasson, MIT Sloan School of Management, Cambridge, MA, 02142, United States, joj@mit.edu, Carri Chan, Sarang Deo, Jeremie Gallien

Community health workers (CHWs) are increasingly important to healthcare delivery in many African countries. Leveraging an extensive dataset featuring time, clinical findings, and GPS information for CHW visits in sub-Saharan Africa, we develop a stochastic model describing the health dynamics of a population served by a time-constrained CHW. We report closed-form solutions quantifying the impact of CHW deployment on public health for a special case and build a heuristic to solve a policy maker s CHW deployment problem.

2 - Learning Decision Rules with Observational Data

Stefan Wager, Stanford GSB, Stanford, CA, 94305, United States

In many areas, practitioners seek to use observational data to learn a treatment assignment policy that satisfies application-specific constraints, such as budget, fairness, simplicity, or other functional form constraints. For example, policies may be restricted to take the form of decision trees based on a limited set of easily observable individual characteristics. In this talk, I will present some recent advances on structured decision-making stochastic systems based on observational data.

3 - Batch Bayesian Optimization for Healthcare Policy Optimization

John M. Silberholz, University of Michigan, Ann Arbor, MI, 02134, United States, Xueze Song

When establishing health policies, policymakers in a number of domains rely on input from comparative modeling exercises, in which multiple independent groups each model a complex health system with the goal of informing the same policy decision. For a variety of reasons, these groups rarely share their model source code or executables, making it challenging to identify the most effective policy decisions when selecting among a large number of possible decisions. In this work, we overcome this challenge using batch Bayesian optimization, and we demonstrate the promise of our approach with an example from prostate cancer screening policy.

4 - Off-service Placement in Inpatient Flow Management

Pengyi Shi, Purdue University, Krannert School of Management, West Lafayette, IN, 47907, United States, shi178@purdue.edu, Jing Dong, Fanyin Zheng, Xin Jin

When waiting time is excessively long before a bed in the primary ward becomes available, patients may be assigned to beds in a non-primary ward. This is referred to as off-service placement. We take a full data-driven approach to study off-service placement by accounting for three salient features: the network structure of the wards, the complex bed assignment decisions, and the casual effect of off-service placement on patient length-of-stay. Our analyses quantify the trade-off between off-service placement and admission delay and generate insights into how the negative impact of off-service propagate through the network.

5 - Financial Incentives under CPC+

Fernanda Bravo, UCLA Anderson School of Management, Los Angeles, CA, 90024, United States, fernanda.bravo@anderson.ucla.edu, Elodie Adida

CMS launched the Comprehensive Primary Care Plus (CPC+) payment initiative, aiming at improving primary care delivery. Under CPC+, physicians are encouraged to use alternative care delivery methods (phone calls, e-visit, in-home nurse visits). We study how CPC+ impacts providers' care delivery decisions, patient welfare, and payer cost.

■ SA65

CC- Tahoma 4

Intersection of Healthcare Policy and Healthcare Operations

Sponsored: Health Applications

Sponsored Session

Chair: Soroush Saghafian, Harvard Univeristy, Cambridge, MA, 02138, United States

1 - Learning Principal Agent Models: Application to Medicare Shared Savings Contracts

Auyon Siddiq, University of California, Los Angeles, CA, 90024, United States, auyon.siddiq@anderson.ucla.edu, Nur Kaynar

Principal-agent models are common in health insurance settings. In this work, we propose an estimator for a general class of principal-agent models where agent actions are hidden. We show the estimator to be statistically consistent and NP-hard. We then present an approximation of the estimator, and propose a solution technique based on column generation that uses non-parametric hypothesis tests to identify variables to introduce into the model. We finally demonstrate the predictive performance of our estimator using empirical data related to a class of widely implemented Medicare contracts.

2 - Nonprofit Versus For-profit: Optimizing Bed Allocations Between Medicare and Medicaid Residents in Nursing Homes

Yangzi Jiang, Northwestern University, Kellogg School of Management, Evanston, IL, 60201, United States, Lauren Xiaoyuan Lu, Jan A. Van Mieghem

Nursing homes in the USA serve two types of residents: (1) Medicare-covered residents with high daily reimbursement rate but short length of stay (LOS); (2) Medicaid-covered residents with low daily reimbursement rate but long LOS. We study how nursing homes react to fluctuations in the demand of these to residents' types to explain the high conversion from nonprofit to for-profit nursing home. Our paper proposes a queueing model to determine the optimal bed allocation policy that maximizes revenue in for-profit nursing homes and that maintains a required service level in nonprofit nursing homes.

3 - The Spillover Effects of Hospital Closures on The Efficiency and Quality of Other Hospitals

Lina Song, Harvard University, Cambridge, MA, 02138, United States, dsong@fas.harvard.edu, Soroush Saghafian

We investigate the impact of U.S. hospital closures on the surrounding hospitals' efficiency and quality. We find that when a hospital closes, its nearby hospitals improve their operational efficiency without expanding their resources. However, they do so via a speed-up behavior (i.e., by reducing their service durations) instead of lowering their average bed idle time. This speed-up response by nearby hospitals negatively affects some aspect of the care (e.g., 30-day patient mortality). Furthermore, hospital closures induce changes in directions that widen social disparity, as their adverse consequences fall disproportionately among hospitals or patients with limited resources.

4 - Can Public Reporting Cure Healthcare? The Role of Quality Transparency in Improving Patient-provider Alignment

Soroush Saghafian, Harvard University, Kennedy School of Government, Cambridge, MA, 02138, United States, soroush_saghafian@hks.harvard.edu, Wallace J. Hopp

Public reporting of medical treatment outcomes is being widely adopted by policymakers in an effort to increase quality transparency and improve alignment between patient choices and provider capabilities. We examine the soundness of this approach by studying the effects of quality transparency on patient choices, hospital investments, societal outcomes (e.g., patients' social welfare and inequality), and the healthcare market structure (e.g., medical or geographical specialization). Our results offer insights into why previous public reporting efforts have been less than fully successful and suggest ways in which future efforts can be more effective.

■ SA66

CC- Tahoma 5

Outpatient Care

Sponsored: Health Applications

Sponsored Session

Chair: Hummy Song, Philadelphia, PA, 19104, United States

1 - Managing Outpatient Care Services with Strategic Walk-in Patients

Nan Liu, Boston College, Chestnut Hill, MA, 02467, United States, nan.liu@bc.edu, Willem van Jaarsveld, Shan Wang, Guanlian Xiao

In addition to serving patients with scheduled appointments, outpatient care providers often set aside some time to see walk-in patients, who arrive without making an appointment in advance. Facing these two channels of accessing care, patients make choices based on their health conditions and the utilities of these two options. In this talk, we discuss how an outpatient care provider should manage her capacity, taking into account such strategic behavior of patients.

2 - Customized Office Revisit Intervals and E-Visits in Primary Care

Hessam Bavafa, Wisconsin School of Business, Madison, WI, 53706, United States, Christian Terwiesch, Sergei Savin

The demand for physician services in primary care is shaped by the number of patients associated with each physician and the frequency of scheduled office visits. While a physician can typically set the size of her patient panel without regard for individual patient preferences, office revisit intervals are determined jointly by the physician and her patients. In our model, a physician can manage the demand for her services using two "customization" approaches: (1) adjusting the office revisit intervals based on patient health status, and (2) diverting some of the patient demand away from the office visits and into "e-visits".

3 - Efficient Transition to Post-acute Care

Alex Mills, Baruch College, City University of New York, New York, NY, 10010, United States, Alex.Mills@baruch.cuny.edu, Jonathan Helm, Pengyi Shi

New payment models are changing the way hospitals arrange for short-stay skilled post-acute care. We show that value-based payment with gainsharing may surprisingly lead patients to be worse off by de-pooling skilled nursing capacity.

4 - Evaluating the Efficacy of Connected Healthcare: An Empirical Examination of the Impact of Patient Engagement and Feedback Systems

Tan Lekwijit, University of Pennsylvania-Wharton School, Philadelphia, PA, 19104, United States, slek@wharton.upenn.edu, Christian Terwiesch, Kevin Volpp

Connected Health (CH) is a form of telehealth in which patients and doctors are connected by means of timely information sharing. The benefits of CH are oftentimes ambiguous. We study CH in a setting where patients received electronic pill bottles and social support that involved different types of feedback. Our work aims to investigate the efficacy of feedback systems in promoting medication adherence, and to establish the relationship between medication adherence and readmission. Our findings suggest that spontaneous manual interventions can effectively turn nonadherence into adherence. Moreover, we also find that better adherence substantially reduces the risk of readmission.

■ SA67

S- Virginia

Case Competition

Award Session

Chair: James J Cochran, University of Alabama, Tuscaloosa, AL, 35487-0226, United States

1 - The Kampala Alternative: Optimizing the Humanitarian Supply Chain in East Africa

Marie-Ève Rancourt, HEC Montréal, 3000 Chemin de la Cÿte Sainte Catherine, Montréal, QC, Canada, Émilie Dufour, Selene Silvestri, Yossiri Adulyasak

The case presents the United Nations Humanitarian Response Depot (UNHRD), its operational context and main challenges, as well as the two options considered to improve its supply chain and reduce costs. Pierre, chief manager of UNHRD, and his team have decided to evaluate two options for optimizing the supply chain: 1) keeping the current network as is and reduce its costs by modifying the service offers and 2) adding a regional storage level to the current network, in Kampala, to serve East Africa. Data are provided to solve this case, inspired from a real problem, by means of optimization techniques.

2 - Suncrest AgriBusiness: Exploiting the Flexibility of Backup Capacity

Saurabh Bansal, Pennsylvania State University, State College, PA, 16801, United States, Philip C. Jones, Timothy J. Lowe

Suncrest was a large agribusiness firm based in the Midwestern United States, with a $1 Billion business focused on seed corn (i.e., the seed that farmers buy to grow corn in their fields). Natural variations result in uncertain yields during the firm's production of seeds. To mitigate the risk of low yield, the firm had acquired a secondary production capability in Chile. This capability could be used to produce the seed if an earlier production in North America had low yields. In this environment, Suncrest needed to determine how to best use both its production capacity in North America and in Chile.

3 - Data-Driven Investment Strategies for Peer-to-Peer Lending

Daniel Guetta, Columbia Business School, New York, NY, United States, Maxime C. Cohen, Kevin Jiao, Foster Provost

We develop a number of data-driven investment strategies that demonstrate how machine learning and data analytics can be used to guide investments in peer-to-peer loans. We detail the process starting with the acquisition of (real) data from a peer-to-peer lending platform all the way to the development and evaluation of investment strategies based on a variety of approaches. We focus heavily on how to apply and evaluate the data science methods, and resulting strategies, in a real-world business setting. The material presented in this case study can be used by instructors who teach data-related courses, at the undergraduate or graduate levels (e.g., decision models, decisions under risk, business analytics). Importantly, we go beyond just evaluating the predictive performance of models, to assess how well the strategies would actually perform, using real, publicly available data. Our treatment is comprehensive and ranges from qualitative to technical, but is also modular—-which gives instructors the flexibility to focus on specific parts of the case, depending on the topics they want to cover. The learning concepts include: data cleaning and ingestion, classification/probability estimation modeling, regression modeling, analytical engineering, calibration curves, data leakage, evaluation of model performance, basic portfolio optimization, evaluation of investment strategies, and using Python for data science. Thus far, this case has been taught to over 200 students at Columbia and NYU, and a number of instructors are considering the case for teaching in their own classes.

■ SA68

S- University

Strategic and Tactical Issues in Warehousing and Logistics

Sponsored: Location Analysis

Sponsored Session

Chair: John Gunnar Carlsson, University of Southern California, Los Angeles, 90089, United States

1 - Inventory Placement in Online Retailing to Reduce Order Splits

Stephen C. Graves, Massachusetts Institute of Technology, Cambridge, MA, 02139-4307, United States, sgraves@mit.edu, Pin Yi Chen

In online retailing when a customer orders multiple items, the retailer tries to supply the order from a single fulfillment center (FC) to reduce shipping costs. This is possible as long as there is a FC that holds all of the times required by the order. When this is not possible, the order is split and the customer will receive multiple shipments from multiple FCs at a much higher shipping cost. We examine how to place inventory across multiple FCs so as to minimize the number of split orders, subject to a limit on how many items can be placed at each FC. We formulate this as an optimization problem and provide theoretical and numerical results on solving this problem for a range of settings.

2 - Asymptotic Bounds on Generalized Traveling Salesman Problem

Mohammad Javad Azizi, University of Southern California, Los Angeles, CA, United States, azizim@usc.edu, John Gunnar Carlsson

Warehouse Traveling Salesman Problem (WTSP) is a special case of generalized Traveling Salesman Problem (GTSP) in a warehouse random stow which gives the shortest path to pick up items for an order. Random Stow systems use a random distribution of inventory, so we studied the probabilistic behavior of GTSP. In particular, given n point sets each with k points in it, we try to bound the tour length of a GTSP which visits (picks up) m items of each point set. Another setting is when tj items of type j are to be picked up. We provide asymptotic upper and lower bounds when n approaches infinity for the tour length and for the average tour length depending on the dimension of the space, d.

3 - The Warehouse Traveling Salesman Problem

Jiachuan Chen, University of Southern California, Los Angeles, CA, United States, jiachuac@usc.edu, John Gunnar Carlsson, Denial karapetyan

The warehouse traveling salesman problem (WTSP) is a generalization of the generalized traveling salesman problem (GTSP). Given disjointed sets of vertices, GTSP is to find the shortest tour that visits exactly one vertex of each set. WTSP is to find the shortest tour that visits arbitrarily required number of vertices of each set, where the required number is pre-determined. The main application is the random stow introduced by Amazon. In our work, we propose two methods to solve the WTSP. The first one is to transform the WTSP to the GTSP, so we can apply GTSP solver to solve WTSP. In addition, we develop a meta-heuristic algorithm called conditional Markov chain search to solve the WTSP directly.

■ SA69

S- Seneca

Learning & Optimization in Healthcare

Sponsored: Manufacturing & Service Oper. Mgmt/Healthcare Operations

Sponsored Session

Chair: Hamsa Sridhar Bastani, Wharton School, Philadelphia, PA, 19104, United States

Co-Chair: Arielle Anderer

1 - Estimating Patient Flow Models via Robust Queueing Theory

Chaithanya Bandi, Northwestern University, Evanston, IL, 60208, United States, c-bandi@kellogg.northwestern.edu

In this paper, we consider the statistical study of partially observed queueing systems arising in application areas such as Hospital networks, data centers, and cloud computing systems. Because these services operate under strict performance requirements, a statistical understanding of their performance is of great practical interest. A key challenge in these settings is that the data are incomplete, because recording detailed information about every request to a heavily used system can require unacceptable overhead. We propose an analytically tractable approach for studying inference problems in these queueing systems. Our approach is based on the Robust Queueing framework.

2 - Fairness under Unawareness: Assessing Disparity with Auxiliary Data when the Protected Class is Unobserved

Xiaojie Mao, Cornell University ORIE, Ithaca, NY, United States, xm77@cornell.edu, Angela Zhou, Nathan Kallus

To assess decision disparity in financial and healthcare sectors when protected class (e.g., race) is unobserved, proxy methods were proposed to impute these missing labels from auxiliary data. We prove that disparity measures are generally unidentifiable even with auxiliary data, which explains the bias and instability of previous methods. Instead of giving point estimates, we provide procedures to learn all valid values of common disparity measures that are consistent with the observed data. We illustrate the effectiveness of our method in two real applications with missing race labels: evaluating the racial disparity of mortgage lending decisions, and of personalized dosing of Warfarin.

3 - Robust Policies for Proactive ICU Transfers

Julien Grand Clement, IEOR Columbia University, New York, NY, 11216, United States, jg3728@columbia.edu

Patients admitted to the ICU after a sudden health deterioration have a higher mortality rate than patients who were admitted proactively. We study the impact of proactive transfer policies (based on patient risk scores) on the clinical outcomes. We show that an optimal strategy is threshold and that a strategy robust to parameters misspecifications can be found among threshold policies too. Using data from real hospitals, we estimate the parameter uncertainty in our model and present numerical experiments where the performances of the hospital can deteriorate even for small parameter deviations. As such, we emphasize the impact of data uncertainty when developing robust versus naive strategies.

■ SA70

S- Jefferson A

How Data Analytics Improve Business Decisions and Management

Sponsored: EBusiness

Sponsored Session

Chair: Angela Aerry Choi, Florida State University, Tallahasse, FL, United States

1 - Context Dependent Preferences and Image Based Deep Learning Recommendations

Andrew Heeseung Lee, Korea Advanced Institute of Science and Technology, Seoul, Korea, Republic of, bsh01250@kaist.ac.kr

The preferences of consumers are often determined by the choice of context in which they engage with products. A product looks more attractive when surrounded by less inviting alternatives, but such appeal diminishes when said product is positioned against more captivating options. On the basis of this contrast effect hypothesis, we evaluated and compared the effectiveness of two recommendation schemes, namely, collaborative filtering (CF) and image-based (IB) deep learning. Specifically, we investigated how consumers' preferences are influenced when a list of recommended fashion products is generated by a hybrid recommendation structure.

2 - The Role of the Entrepreneur's Video Pitch in Online Crowdfunding

Jiyong Park, University of North Carolina at Greensboro, Greensboro, NC, United States, jiyong.park@uncg.edu, Jongho Kim, Daegon Cho

Although a video is an essential channel to persuade funders, little is known about the role of video pitches in online crowdfunding. This study examines how a video pitch influences crowdfunding performance. We leverage a range of state-of-the-art machine learning techniques that enable us to not only gauge speech styles but explicitly account for content heterogeneity in both text and video. Using data from over 4,500 crowdfunding projects, we find that an entrepreneur's pitch and its nuanced styles play important yet distinct roles in increasing pledged amounts and social buzz via social media. This study demonstrates an empirical application of machine learning in online content engineering.

3 - "Need for Speed", But How Much Does It Cost? Fee-Speed Relationship on Bitcoin Transactions

Guangzhi Shang, Noyan Ilk, Florida State University, Tallahassee, FL

We study the transaction fee and confirmation speed relationship on Bitcoin. We propose a priority indexing based framework, estimate this framework, and use this framework to recommend transaction fees.

■ SA71

S- Jefferson B

Supply Chain Management I

Contributed Session

Chair: Vashkar Ghosh, University of North Carolina, Greensboro, Greensboro, NC, 27402, United States

1 - Empirical Investigation of Bullwhip Effect with Sensitivity Analysis in Supply Chain

Shoaib Yousaf, International Islamic University, Islamabad, Pakistan, shoaib.phdtm19@iiu.edu.pk

This paper empirically investigate the bullwhip effect under sensitivity analysis in two tier supply chain in the rice industry of Pakistan. Simulation has been applied with two case studies. The results confirmed that reduction in production delay, increasing the value of time to adjust inventory, reducing the value of time to work in progress also reduces the bullwhip effect. Furthermore, by decreasing the value of alpha increases the damping effect. Moreover, this research will help to reduces the major costs of their products in three ways, i) inventory levels, ii) better utilize their capacity and iii) improve their forecasting techniques.

2 - Quantifying the Bullwhip Effect in NAIJI Production System

Nobuyuki Ueno, Hiroshima University of Economics, Hiroshima, Japan

We present both the model to quantify the demand amplification and the way to dampen it in NAIJI production system between an automobile manufacturer and suppliers. In NAIJI production system, the manufacturer weekly and monthly sends NAIJI (Forecast) in advance of supplier's manufacturing and the supplier makes production plans, but NAIJI is known to be uncertain and changing. We developed the demand model based on NAIJI and the formula for the bullwhip effect ratio depending on only demand fluctuation. And we compared the result by the formula with measurement and the precedent study.

3 - Inter and Intra-firm Bullwhips in a Multi-echelon Pharmaceutical Supply Chain

Ming Jin, University of Oregon, Eugene, OR, United States, mjin2@uoregon.edu, Nicole DeHoratius, Glen M. Schmidt

We investigate the bullwhip effect in a pharmaceutical supply chain using SKU-level data across four echelons: customers, distributors, a manufacturer, and suppliers. We empirically measure intra-firm bullwhips across multiple echelons of the supply chain. The bullwhip measurement based on information flow is larger than that based on material flow. Data aggregation across products or over long time periods tends to mask the bullwhip effect. We find that price variation, replenishment lead time, and inventory are three main factors associated with the bullwhip effect.

4 - Strategic Inventories and Vertical Contracts in Multiechelon Supply Chains

Qing Wu, University of Electronic Science and Technology of China, Chengdu, Sichuan, China, wuq@uestc.edu.cn

Established findings suggest that strategic inventory may alleviate double marginalization and improve the efficiency of a decentralized two-echelon supply chain. However, the role of strategic inventory in multi-echelon supply chains remains largely unexplored. In this paper, we examine the effect of strategic inventory in multi-echelon supply chains.

5 - Impacts of Leadership on CSR Management in Multi-tier Supply Chains

Wanying Wei, Tianjin university, Tianjin, China, weiwanying@tju.edu.cn, Weihua Liu, Tsan-Ming Choi

Considering two different supply chain leaderships: 1) Tier 1 leads Tier 2 supplier and 2) Tier 2 leads Tier 1 supplier, we study when the Tier 0 should entrust the Tier 1 supplier (delegation strategy) or directly motivate the Tier 2 supplier (control strategy) to decrease the CSR violation probability in Tier 2. Contrary to studies intuitively arguing that delegation is more efficient when Tier 1 supplier is in the leading position, we find in some cases, delegation strategy is more likely to ensure a lower violation probability when Tier 2 leads Tier 1.

6 - Pricing Strategies and Asymmetric Information

Vashkar Ghosh, University of North Carolina-Greensboro, Greensboro, NC, United States

We consider information sharing in a supply chain and investigate its effect on different pricing strategies.We develop a model to analyze the preference of each channel member towards sharing information.The analysis examines the effect of competition and information asymmetry on supply chain profits.

■ SA72

S- Columbia

MIF Early Career Award

Sponsored: Minority Issues

Sponsored Session

Chair: Julie Simmons Ivy, North Carolina State University, Raleigh, NC, 27695-7906, United States

1 - Queueing Theory for Service Systems and Society

Jamol Pender, Cornell University, Ithaca, NY, 14850, United States

Queues are all around us. In this talk, we will describe how queueing theory is used to understand how long customers will wait in line and how this information is disseminated to customers for their use. We will show that sometimes giving information to customers can be detrimental and therefore, it is important to understand the impact of the information that is presented to customers. The talk will also highlight the fact that this research was driven by a diverse set of students, collaborators and has had a large impact in a variety of application areas such as healthcare, amusement parks, and autonomous vehicles.

■ SA73

S- Boren

Machine Learning and Rough Volatility

Sponsored: Finance

Sponsored Session

Chair: Justin Sirignano, University of Illinois at Urbana-Champaign, Urbana IL, United States

Co-Chair: Alexandra Chronopoulou

1 - A New Model for Stock-Price Trend Analysis and its Exploitation in Trading

James A. Primbs, California State University-Fullerton, Fullerton, CA, United States, B. Ross Barmish

In this work we put forward a new model for stock-price trend analysis which, rather than describing the extent to which a stock price goes up or down, provides a quantification of the duration of trends and the extent to which "efficient" entry points are available for traders. We illustrate how such a model might be used by traders who strategically switch between long and short positions to exploit suitably long trends. Finally, we provide an explicit formula for the expected gain or loss of such a trader over a single trend, and provide numerical examples exploring the possible exploitation of "microtrends" at the stock transaction level.

2 - Personalized Robo-advising

Agostino Capponi, Columbia University, New York, NY, 10027, United States

Automated investment platforms, or robo-advisors, have emerged as an alternative to traditional financial advisors. Their viability depends in a crucial way on the efficiency of the communication exchange between the investor and the machine. We develop a novel robo-advisor algorithm that solves a dynamic version of the mean-variance investment criterion and also adapts over time to changing risk-preferences of the investor it serves. We quantify the trade-off that the investor faces between the cost of updating risk-preferences, i.e. communicating with the machine, and the benefit of obtaining investment advice that is more tailored to her risk profile. We study the regret measures arising from the robo-advisor's imperfect knowledge of the investor's risk profile and analyze their sensitivities to market and human-machine interaction.

3 - Optimal Sampling Schemes in Fractional Volatility Models

Alexandra Chronopoulou, University of Illinois-Urbana-Champaign, Urbana, IL, 61801, United States

The goal of this talk is to propose efficient sampling schemes for sampling fractional (both rough and long memory) stochastic volatility models, when the number and type of observations is constrained due to limited resources. We find that the sampling mechanism depends on the value of the Hurst parameter, H, and that the equidistant sampling scheme is optimal only when H=0.5.

4 - Global Convergence of Stochastic Gradient Hamiltonian Monte Carlo for Non-Convex Stochastic Optimization

Lingjiong Zhu, Florida State University, Tallahassee, FL, 32306, United States

Stochastic gradient Hamiltonian Monte Carlo (SGHMC) is a variant of stochastic gradient with momentum where a controlled and properly scaled Gaussian noise is added to the stochastic gradients to steer the iterates towards a global minimum. Many works reported its empirical success in practice for solving stochastic non-convex optimization problems from machine learning, in particular it has been observed to outperform overdamped Langevin Monte Carlo-based methods such as stochastic gradient Langevin dynamics (SGLD) in many applications. In this work, we provide finite-time performance bounds for the global convergence of SGHMC for solving stochastic non-convex optimization problems with explicit constants. Our results lead to non-asymptotic guarantees for both population and empirical risk minimization problems. For a fixed target accuracy level, on a class of non-convex problems, we obtain iteration complexity bounds for SGHMC that can be tighter than those for SGLD. These results show that acceleration with momentum is possible in the context of non-convex optimization algorithms. This is based on the joint work with Xuefeng Gao (Chinese University of Hong Kong) and Mert Gurbuzbalaban (Rutgers University).

■ SA74

S- Capitol Hill

Supply Chain Management II

Contributed Session

Chair: Jizhou Lu, Central University of Finance and Economics

1 - A Text Analytics Based Review of the Supply Chain and Operations Literature

Thomas Robbins, East Carolina University, Greenville, NC, United States, robbinst@ecu.edu

In this talk we present a review of the academic literature in supply chain and operations management. We have collected summary data that includes the title, authors, keywords, and abstracts for papers published in 18 top tier journals that publish SC&OM research. Using a data set of over 38,000 articles published over the last 25 years we perform a text analytics-based review. We analyze the data to determine the most prevalent methodologies and topic areas addressed. We also use this data to perform a cluster analysis to segment the journal set.

2 - Physical Asset Management (PAM) Based Decision Making Platform in the Utility Sector; the Case of Fluvius

Amir-Behzad Samii, Vlerick Business School, Brussels, Belgium, behzad.samii@vlerick.com, Olga Varganova

Physical Asset Management (PAM) is the systematic and structured process of planning, designing, and controlling the physical assets during their life-cycle to support the delivery of goods and services. We model the total supply chain costs of the physical assets and develop a PAM-based decision-making platform for the Belgian utility provider Fluvius. We showcase the applicability of this platform in evaluating the smart electricity and gas meters implementation projects as well as the proliferation of the renewable energy assets.

3 - Reconfiguration of Manufacturing Supply Chains Considering Outsourcing Decisions and Supply Chain Risks

Qi Tian, Dalian University of Technology, Dalian, China, tianqidlut@163.com

In order to stay responsive to evolving demands and to meet the need for greater product customizations, many manufacturing enterprises are recognizing the need to quickly reconfigure their manufacturing systems and supply chains. This study proposes a graph-based cost model to optimize the configuration of manufacturing supply chain networks to support reconfiguration decisions. We aim to minimize the total cost of the manufacturing enterprise considering operating cost and reconfiguration cost. The graph-based model characterizes the relationship between the similarity of two supply chain networks and the reconfiguration cost. Outsourcing options and risks are also considered.

4 - Evaluating Efficiency and Efficacy for Different Delivery Strategies

Sanam Azadiamin, Ohio University, Athens, OH, United States, sa349416@ohio.edu

Many stores now offer delivery directly to customers' homes. This needs to be done with a low cost while providing high customer satisfaction. This research examines different routing strategies and evaluates how each performs in terms of efficiency and efficacy. The work also examines the impact of waiting for more orders before forming routes, which results in a longer lead time for the customer and therefore, worse efficacy. The results show that the efficiency of the route is primarily dependent on the number of orders in the route and doesn't show significant improvement when the population of orders to be batched is larger.

5 - Information Sharing and Information Quality in Parallel Supply Chains

Jizhou Lu, Assistant Professor, Central University of Finance and Economics, Beijing, China

We consider two parallel supply chains. Each one consists of one manufacturer and one retailer. The demands of two products sold by retailers are interdependent and respectively follow a first order vector autoregressive process. We consider two types of information sharing here: inter-supply chain information sharing and cross-supply chain information sharing. Meanwhile, information errors would happen while information is being shared. We propose an analytical framework to study how the value of information sharing is affected by information errors. We identify the conditions under which the value of information sharing is increased or decreased.

■ SA77

S- Fremont

Modern Project Management

Emerging Topic: Project Management & Scheduling

Emerging Topic Session

Chair: Marc E. Posner, Ohio State University, Columbus, OH, 43210-1271, United States

1 - Optimal Hedging in the Stochastic Time Cost Quality Tradeoff Problem

Bruce Pollack-Johnson, Associate Professor of Mathematics and Statistics, Villanova University, Villanova, PA, United States, bruce.pollack-johnson@villanova.edu, Matthew J. Liberatore

We present the Stochastic Time Cost Quality Tradeoff Problem (STCQTP) model to optimally hedge against time and cost uncertainty in project scheduling, incorporating a continuous quality function with stochastic parameters.

2 - Early Termination Compensation under Demand Uncertainty in Public-Private Partnership Projects

Jinbo Song, Dalian University of Technology, Dalian, China, songjinbo@dlut.edu.cn

In the early termination of public-private partnership projects, compensation is considered a core issue that affects the interests of the government and the private sector. To address the early termination that is frequently caused by government default or voluntary buyback, this paper proposes an ex-ante compensation mechanism using the cumulative probability that a given demand could be realized to determine early termination compensation under demand uncertainty. By splitting the compensation into two parts, the base compensation could be the minimum compensation for the private sector, while the additional compensation is considered a reasonable allocation of future booming demand.

3 - Preemptive Resource Leveling

Marc E. Posner, Professor, Ohio State University, Columbus, OH, 43210-1271, United States, posner.1@OSU.edu, Nicholas G. Hall

We examine the resource leveling problem where job splitting is permitted. The complexity of several variants of the problem are examined. Also, we provide bounds on the relative performance of the non-preemptive and the preemptive versions of the problem.

■ SA78

S- Greenwood

Crowdfunding Platforms

Sponsored: New Product Development

Sponsored Session

Chair: Simone Marinesi, Wharton, Philadelphia, PA, 19103, United States

1 - Signaling to the Crowd: Private Quality Information and Rewards-based Crowdfunding

Soudipta Chakraborty, Duke University, Durham, NC, 27708, United States, sc390@duke.edu, Robert Swinney

We consider the problem faced by a creator designing a rewards-based crowdfunding campaign via a platform like Kickstarter. The creator solicits pledges from backers, and if total pledges exceed a pre-determined threshold, the campaign is successful, the creator receives all pledges and each backer receives a reward. Otherwise, the campaign fails, and backers are refunded their pledges. We determine how the creator should design her campaign when backers know less than her about the value of the reward.

2 - Crowdfunding vs. Bank Financing under Market Uncertainty

Fasheng Xu, Washington University in St. Louis, Campus, Saint Louis, MO, 63130, United States, fasheng.xu@wustl.edu, Xiaomeng Guo, Guang Xiao, Fuqiang Zhang

Bank financing is a traditional source of capital for small businesses, whereas crowdfunding has recently emerged as an alternative fund-raising solution to support innovative ideas and entrepreneurial ventures. This paper investigates a firm's optimal funding choice when launching an innovative product to the market with both market uncertainty and word-of-mouth (WoM) communication. We characterize the firm's optimal pricing strategies under the two funding choices (i.e., bank financing and crowdfunding), compare their performances, and investigate the corresponding implications on social welfare.

3 - Crowdfunding: Public Signal for Venture Capital

Jussi Keppo, National University of Singapore, Mochtar Riady, Singapore, 119245, Singapore, keppo@nus.edu.sg, Ming Hu, Yannan Jin

Motivated by the empirical observation of the relationship between crowdfunding and Venture Capital (VC) investments, we study how crowdfunding, as a public information source, affect competing VCs' investment strategies. We show that crowdfunding and competition between VCs raise VC investments. Further, if the downside risk of the startup is severe and if the precision of the crowdsourcing information is high, then the more optimistic VC is more likely to invest before the crowdfunding. Our results are robust in several model extensions.

4 - Designing Crowdfunding Platform Rules to Deter Misconduct

Simone Marinesi, University of Pennsylvania, Philadelphia, PA, 19103, United States, marinesi@wharton.upenn.edu, Elena Belavina, Gerry Tsoukalas

Lacking credible rule enforcement mechanisms to punish misconduct, existing reward-based crowdfunding platforms can leave backers exposed to two risks: entrepreneurs may run away with backers' money (funds misappropriation) and product specifications may be misrepresented (performance opacity). To mitigate these risks, we propose and analyze a variety of designs that involve the use of deferred payments, and possibly also include costly performance verification checks, varying the timing (pre- vs. post-campaign) and enforcement rules (mandatory vs. optional). Overall, we analyze ten different designs and show that eight of them are dominated and only two designs dominate.

■ SA79

S- Issaquah A

Joint Session: Sustainable Growth/MIF: Energy for Increasing Social Good

Emerging Topic: Sustainable Growth

Emerging Topic Session

Chair: Destenie Supreece Nock, University of Massachusetts-Amherst, Amherst, MA, 01035, United States

1 - Fairness in Energy Access Initiatives

Valerie Thomas, Georgia Tech, ISYE, Atlanta, GA, 30332, United States, vthomas@isye.gatech.edu

The UN's Sustainable Development Goals include access to clean and affordable energy. Energy access programs in developing countries have included varying approaches to fairness and to technology. Many electricity production planning models choose the technology options, assume that unmet demand exists, and that providing electricity will result in societal benefits. Demand in developing countries has often failed to meet expectations. An alternative approach emphasizes productive use of electricity. Models contrasting these approaches will be presented. Social metrics used in sustainability and social sciences are introduced.

2 - Valuing System Flexibility: Pumped Hydro Storage in the New England Electricity System

Destenie Supreece Nock, Postdoctoral Researcher, Carnegie Mellon University, Pittsburgh, PA, 01035, United States

Pumped hydro energy storage is one method of enhancing power system flexibility due to its ability to regulate power output from renewables, acting as a supplier and consumer, and enhance overall system sustainability through enhancing the capacity factor of renewables and being a low emission technology. In this paper we determine the value of PHES using multi-criteria decision analysis and the three pillars of sustainability. We rank low carbon generation portfolios under nine-illustrative preference scenarios. We find that using PHES to support renewables proves beneficial for the region, and we present our framework for quantifying the sustainability of flexible power systems.

3 - Using Value-focused Thinking and Multi-criteria Group Decision-making to Evaluate Energy Transition Alternatives

Tim Höfer, RWTH Aachen, Aachen, Germany, Rüdiger von Nitzsch, Reinhard Madlener

We develop a group decision-making process with professional stakeholders and energy experts to evaluate possible energy transition alternatives. The stakeholders are involved in every step of the decision-making process - the development of the alternatives, the definition of the objective system, and the final evaluation of the alternatives. We apply Value Focused Thinking (VFT) to define and structure the objectives of the stakeholders and use Multi-Attribute Utility Theory (MAUT) to evaluate the alternatives. The results show that a majority of the stakeholders prefers the energy transition alternative, which has the highest ambitions to limit climate change.

4 - Least-cost Pathways for The Indian Power Sector

Maxwell L. Brown, National Renewable Energy Laboratory, Arvada, CO, 80002, United States

Increased deployment of variable renewable energy raises new questions related to optimal siting of generation capacity, tradeoffs between generation and transmission, and system flexibility needs. In this analysis, we use the Regional Energy Deployment System (ReEDS) model to evaluate least-cost pathways for India's electric power system over the period 2017-2047. We showcase the impact of different future trends (e.g., storage, transmission) on power sector investments. This work represents the first international application of ReEDS as part of an effort to strengthen institutional capacity within India.

■ SA80

S- Issaquah B

OR/MS Models in Innovation and Entrepreneurship

Sponsored: Technology, Innovation Management & Entrepreneurship

Sponsored Session

Chair: Stefanos Zenios, Stanford University, Stanford, CA, 94305-5015, United States

1 - Anticipating Random Walks: A Dynamic Model of Crowdfunding

Mohamed Mostagir, University of Michigan, Ann Arbor, MI, 48109, United States, Saeed Alaei, Azarakhsh Malekian

This talk introduces a novel stochastic process — anticipating random walks — to analyze backer behavior in crowdfunding. The analysis helps explain why some campaigns fail and some do not and provides guidelines about how sellers should design their campaigns in order to maximize their chances of success.

2 - Does Blockchain Facilitate Responsible Sourcing? Case of Supply Chain of Diamonds

Dmitrii Sumkin, INSEAD, Singapore, 138676, Singapore, dmitry.sumkin@insead.edu, Sameer Hasija, Serguei Netessine

Recently, blockchain was implemented in diamonds supply chain to validate certificates of origin. We examine how it affects responsible production. We model customers valuing both responsible production and reselling opportunity provided by the certificate. We show that with blockchain certificates it is less profitable to segment the market by the reselling opportunities than by responsible production. Thus, blockchain certification can reduce or increase responsibility in supply chains. Moreover, we demonstrate that different certification policies can make the negative effect of blockchain even worse.

3 - Entrepreneurial Search as a Sequential Hypothesis Test with Multiple Controls

ZhenglI Wang, Graduate School of Business, Stanford University, Stanford, CA, United States, Stefanos Zenios

We consider a problem in which an entrepreneur decides whether to launch a given project. The decision maker can choose to acquire different types of signals to learn whether the project is valuable, at different costs. We provide both the Bayesian and the frequentist approaches to the problem under Brownian approximations. We then derive the optimal policy and provide insights on the structure of the policy.

4 - The Indirect Role of Social Comparisons in the Adoption of New Practices in Organisations Using an Evolutionary Game Theory Approach

Antoine Feylessoufi, University of Cambridge, Cambridge, United Kingdom, af545@jbs.cam.ac.uk

We propose an evolutionary game theoretic model of the micro behaviours of individual employees that are faced with the option of adopting a new practice in an organization. We develop insights regarding the potential of an organization to successfully and fully adopt a new management practice or operational technology and show that the interplay between (i) the social comparison effects on individual utilities, as these are dictated by the underlying organizational culture (envious vs. gloating), and (ii) the formal collective rewards instituted by the organization to induce adoption (bonus vs. levy) shape the eventual adoption patterns inside the organisation.

■ SA81

S- Kirkland

Forestry I: Forest Management

Sponsored: Energy, Natural Res & the Environment/Forestry

Sponsored Session

Chair: Sandor Toth, University of Washington-Seattle, Seattle, WA, 98195-2100, United States

Co-Chair: Cristóbal Pais, M. Sc, UCBerkeley, Berkeley, CA, United States

1 - Sampling Design Optimization for Measuring Forest Carbon

Sandor Toth, University of Washington-Seattle, Seattle, WA, 98195-2100, United States

We seek to optimize spatial sampling design for forest carbon measurements from both remote and ground-based sensors. Expected measurement error is to be minimized subject to budgetary and logistical constraints. To mitigate bias, our proposed integer programming model generates optimal plot inclusion probabilities. The implementation of the probabilistic sampling solutions can lead to budget overruns, however. We demonstrate how to mitigate such scenarios by tuning the parameters of the model for a case study.

2 - Economies of Scale in Forest Cutting Models via 0-1 Quadratic Objectives

Monique Guignard, Professor, Wharton, University of Pennsylvania, Philadelphia, PA, United States, Andres P. Weintraub, Antonio Alonso Ayuso

In plantations, the total cost of cutting two contiguous forest lots in different periods may be reduced if they can be cut in the same period, as economies of scale may then be created by using the same cutting and/or road building equipment. We review such issues as pairs of lots of different maturity, nonoverlapping pairs, and which map information to store to automate model creation.

■ SA82

S- Leschi

Policy Intervention to Firms' Sustainability Actions

Sponsored: Energy, Natural Res & the Environment/Environment & Sustainability

Sponsored Session

Chair: Kejia Hu, Vanderbilt University, Nashville, TN, 37215, United States

Co-Chair: Huibin Du, Tianjin University, Tianjin, 300072, China

1 - Warning Against Recurring Risks: An Information Design Approach

Shouqiang Wang, The University of Texas at Dallas, Naveen Jindal School of Management, Richardson, TX, 75080, United States, Shouqiang.Wang@utdallas.edu, Saed Alizamir, Francis E. De Vericourt

Public agencies typically emit warnings to the stake-holders about potential disastrous events. In a repeated setting, they need to incentivize the public to take preventive actions in the current period while managing their credibility in the future. We characterize the optimal warning policy that balance such a tradeoff.

2 - The Unexpected Consequences of Regulation-driven Innovations Evidence from Auto Industry

Kejia Hu, Vanderbilt University, Nashville, TN, 37215, United States, Mark Cohen

We use 10-year vehicle emission dataset to study the pro-social and anti-social innovations under the tightening of emissions standards.

3 - An Agent-based Analysis of the Impact of Carbon Emission Trading on Power Sector: Prospects of China's Low-carbon Electricity

Huibin Du, Tianjin University, Nankai District, Tianjin, 300072, China, duhuibin@tju.edu.cn

The design of emission trading system is still obscure in China. Power companies are pushed to participate in the system, and they are concerned about future investment directions, as they do not understand the impact of such a system. This paper used agent-based modeling to simulate the carbon emission trading system implemented in China's power sector and investigate its impact on the future development of power sector. The results show that emission trading system can promote a virtuous cycle between emission reduction and renewable energy investment. The behavior characteristics of power companies are identified, which can assist the government to design an applicable emission trading system.

4 - Innovation Pressure Through the Supply Chain Network

Kejia Hu, Vanderbilt University, Nashville, TN, 37215, United States

We study how innovation pressure from regulators are spread through the supply chain network and examine how such network effect is changed under different buyer-supplier relationship.

■ SA83

S- Medina

Joint Session ENRE/Elec/Practice Curated: Cyber and Physical Resilience in Power Systems

Sponsored: Energy, Natural Res & the Environment/Electricity Sponsored Session

Chair: Feng Qiu, Argonne National Laboratory, Lemont, IL, 60439, United States

1 - A Resilient and Trustworthy Cloud and Outsourcing Security Framework for Power Grid Applications

Feng Qiu, Argonne National Laboratory, Lemont, IL, 60439, United States, fqiu@anl.gov, Alinson Xavier

Cloud provides a powerful and scalable IT infrastructure for industrial computational needs. As many sectors are moving enterprise applications to cloud, power sector is very slow in this progress. The reason is that, power system applications involve highly sensitive data concerning critical infrastructure security; but cloud is not a trustworthy computational infrastructure due to the "shared responsibility security model". We propose a trustworthy cloud computing framework based on privacy-preserving computation methods. We will use security-constrained unit commitment as an example and discuss the tradeoff between security and computational performance.

2 - Accelerating Bulk Power System Restoration Using Valid Inequalities

Bai Cui, Argonne National Laboratory, 532 Inverrary Ln, Lemont, IL, 60015, United States

The ability to promptly restore power services after blackouts is crucial for power system resilience. However, the process of bulk power system restoration is extremely complex, which involves multiple sequential steps, highly combinatorial operational decisions, and highly nonlinear network constraints. In this presentation, we introduce a mixed-integer linear programming-based formulation for optimal restoration sequence problem using linearized power flow equations. We discuss an approach to strengthen the formulation and improve the computational performance by exploiting a node-based substructure in the formulation.

3 - Quickest Detection of Cascading Failure

Rui Yao, Argonne National Laboratory, Lemont, IL, United States, Rui Zhang

We consider the problem of detecting the cascading failure in power system. We propose a temporal model for the diffusion of the failure. Under this model, the hazard rate of a node increases as the number of failure neighbors increases. Once failure affects a node, the distribution of the measurement changes from pre-change distribution.

■ SA84

S- Ravenna A

Develop HPC Based Algorithms for Energy Applications

Sponsored: Energy, Natural Res & the Environment/Energy Sponsored Session

Chair: Feng Pan, Pacific Northwest National Laboratory

1 - Applying HPC Based HIPPO Software for Future Market Development Evaluation

Yonghong Chen, Midcontinent ISO, Carmel, IN, 46032, United States, ychen@misoenergy.org

This talk discusses how MISO uses HPC based HIPPO software to develop prototypes for future market scenarios and enhancement models. HIPPO includes libraries of formulations and solution approaches for security constrained unit commitment. New market enhancements are included through enhanced resource and system constraint options. It helps MISO to evaluate market impact from different design options and performance impact on market clearing software.

2 - Fast Evaluation of Security Constraints in a Security Constrained Unit Commitment Algorithm

Jesse T. Holzer, Pacific Northwest National Laboratory, Richland, WA, United States, jesse.holzer@pnnl.gov, Yonghong Chen, Feng Pan, Ed Rothberg, Arun Veeramany

We present a new fast security constraint evaluation (SCE) method and show how it facilitates algorithms for security constrained unit commitment (SCUC) problems in a large day ahead electricity market. Our SCE method achieves speedup on the order of 10x to 100x relative to existing commercial methods currently used in this context. This speedup permits the use of SCE as an integrated part of an algorithm for SCUC rather than in alternation with an SCUC algorithm, giving greater flexibility in the design of SCUC algorithms.

3 - Moving the Lower Bound for Unit Commitment MIP Models

Edward Rothberg, Gurobi Optimization, Beaverton, OR, 77027, United States, rothberg@gurobi.com

When considering their size, numerical complexity, and runtime constraints, unit commitment models are among the toughest MIP models that are currently being solved. Solving a MIP of course requires progress in both the lower and upper bound. This talk will discuss some of the approaches we have tried to improve the lower bound more quickly. We'll present computational results for the most effective of these approaches.

4 - On Lower Bounds for MIP-based Unit Commitment Problem

Yanan Yu, University of Florida, Gainesville, FL, 32603, United States, yuyn@ufl.edu, Yongpei Guan

With the development of mixed integer programming (MIP) solvers, MIP-Based Unit Commitment(UC) formulation and algorithm, such as branch-and-bound, have shown promises. To solve a minimization problem and evaluate the quality of a feasible solution in the branch-and-bound algorithm, a lower bound is needed. Improving the lower bound can help shorten the solving time. In this talk, we provide a comprehensive overview of lower bounds for MIP-Based UC formulations. The existed methods are tested on IEEE118 cases and real-world instances. By taking advantage of HPC, we contribute a parallel branching algorithm. The efficiency of the provided algorithm is verified by real-world cases.

5 - Exploiting Almost Symmetry in the Unit Commitment Problem

Jonathan Schrock, University of Tennessee, Knoxville, TN, United States, Jim Ostrowski, Yonghong Chen, Bernard Knueven

Unit commitment (UC) is a central problem in the operation and planning of real-world power systems. The UC problem is to develop an operating schedule for a system of generating units to meet forecasted load while minimizing production costs and satisfying physical and operational constraints. Such units with the same operating parameters and costs are called symmetric. Those that agree on all parameters excluding cost are called almost symmetric. In this work, we utilized these almost symmetries to reformulate the UC problem into a reduced form that can be solved more efficiently. We then applied Benders style cuts iteratively to tighten the model and retrieve a solution to the original UC problem.

6 - A Concurrent Optimizer for Solving Security Constrained Unit Commitment Problem

Feng Pan, Pacific Northwest National Laboratory, Richland, WA, 99352, United States, feng.pan@pnnl.gov, Yonghong Chen, Jesse Holzer, Edward Rothberg, Jie Wan

HIPPO is an ARPA-E funded project aiming to develop efficient algorithmic technologies to solve security constrained unit commitment problem with tenfold increase from the speed of the current solver. The core of the HIPPO software is a concurrent optimizer which manages parallel execution of a suit of algorithms and communication among individual algorithms. In this talk, we will introduce the concurrent optimizer and the underlying solution approaches and demonstrate its performance on a set of MISO market cases which were validated with GE and MISO's production solver.

■ SA85

S- Ravenna B

Balancing Economic and Environmental Goals in Assessing Energy Futures

Contributed Session

Chair: Max Brozynski, University of Texas, Austin, TX, 78704, United States

1 - Electricity Market Impacts of Carbon and Variable Renewable Energy Policies

Todd Levin, Argonne National Laboratory, Lemont, IL, United States

We apply a computationally-efficient generation expansion planning model to a case study of ERCOT. We analyze the market impacts of policies that support VRE investments and carbon reductions. We find that electricity prices vary between policies, even when generation portfolios are comparable. A carbon tax is more system cost-efficient for reducing carbon emissions, while production and investment tax credits are more system cost-efficient for increasing VRE investments. Policies that reduce prices may require additional capacity remuneration mechanisms more than policies that increase prices. Moreover, impacts to consumer payments are not always aligned impacts to system cost.

2 - Utility-scale Photovoltaics and Storage: Economic and Environmental Trade-offs

Edgar Virguez, PhD Candidate, Duke University, Durham, NC, United States, edgar.virguez@duke.edu, Dalia Patino-Echeverri

This study explores the performance of the Duke Energy Progress/Carolinas electric power system under eighty-five configurations combining different capacities of utility-scale photovoltaics (PV) and energy storage. Results indicate that minimum carbon abatement costs are obtained when PV installed capacity is paired with batteries whose power capacity is ~12.5%. For levels of PV penetration (measured as expected annual share of energy) above 17%, higher decarbonization targets are better pursued with increased storage capacity than with more PV. For more ambitious targets (e.g. >30%), carbon dioxide emissions reductions require increases in both PV and storage capacity.

3 - The Performance of NYC's Transportation Policies in the Context of Their 80x50 Targets

Mine Isik, Postdoctoral Researcher, US EPA, Durham, NC, United States, Ozge Kaplan

The demand for mobility propelled by population put the transportation sector at the forefront of city planning. Policy makers confront vital health challenges while designing more sustainable cities and maintaining the mobility demand. The New York City alongside being the most populous city is experiencing a significant increase in travel demand. A community scale, cost optimization linear programming MARKAL model EPANYC6r that focuses on transportation sector, and energy infrastructure for NYC is developed. This study highlights the performance of transportation policy options and alternative technology investment decisions on its 80x50 goals considering CO_2, NO_x and SO_x emissions.

4 - A Game-theoretic Model of Infrastructure-dependent Technology Adoption: Overcoming the Chicken-and-egg Problem

Max T. Brozynski, University of Texas-Austin, Austin, TX, United States, brozynski@utexas.edu

Large technical systems, e.g., transportation, feature infrastructure-dependent technologies that are highly resistant to technology transitions because of lock-in phenomena that are exacerbated by the substantial sunk cost of existing infrastructure. To support an infrastructure-dependent technology transition, a policymaker must therefore overcome the chicken-and-egg problem: does adoption precede infrastructure, or vice-versa? To address this question, we formulate a general game-theoretic model of infrastructure-dependent technology adoption. Our analytical results shed light on the policymaker's and infrastructure provider's optimal strategic decision-making.

■ SA86

S- Ravenna C

Modeling Decarbonization of Energy Systems

General Session

Chair: Ramteen Sioshansi, The Ohio State University, Columbus, OH, 43210-1271, United States

1 - A LP-based Model for Projecting Downscaled Power Plant Emissions from NEMS Model Runs

Benjamin Field Hobbs, Schad Chaired Professor, Johns Hopkins University, Baltimore, MD, 21218, United States, bhobbs@jhu.edu, Shen Wang, Xinrui Zhong

The National Energy Modeling System projects power plant capacity, outputs, and emissions by large regions for 12 time slices per year. However, for fate and transport analyses of pollution impacts, it is necessary to downscale those emissions in time and space. A LP- and geostatistics-based scheme for accomplishing this downscaling through the year 2040 is proposed and illustrated. The downscaling results show that alternative scenarios concerning electric vehicle and natural gas penetration can have signicant impacts on the timing and location of projected emissions.

2 - Strategic Storage Use in a Hydro-thermal Power System with Carbon Constraints

Afzal S. Siddiqui, University College London, Department of Statistical Science, Gower Street, London, WC1E 6BT, United Kingdom, afzal.siddiqui@ucl.ac.uk, Sebastien Debia, Pierre-Olivier Pineau

New York and Québec have a high penetration of variable renewable energy sources (VRES) and hydro production, respectively, along with stringent carbon caps. While cap-and-trade policies have increased VRES generation, they have also enhanced the role of energy storage, viz., by hydro reservoirs. Storage capacity should be deployed in a socially optimal way to smooth out fluctuations in VRES output, but hydro reservoirs may be used strategically as a result of market power. Consequently, incentives for VRES and welfare may be affected by such exertion of market power. We investigate the extent of these distortions and propose policies for their mitigation via a bottom-up equilibrium model.

3 - Using Geologically Stored Co2 and Geothermal Energy to Decarbonize the Electricity System

Jonathan Ogland-Hand, ETH-Zurich, 5363 Amy Lane, Zurich, 43235, Switzerland, Jeffrey Bielicki, Ebony Nelson, Benjamin Adams, Thomas Buscheck, Martin Saar, Ramteen Sioshansi

CO2-Bulk Energy Storage (CO2-BES) uses geologically stored CO_2 to extract geothermal heat in a way that time-shifts electricity production. We used an integrated model of a CO2-BES facility to determine the maximum duration over which electricity could be time-shifted and then used those results to investigate the value that CO2-BES may have in a transmission-constrained electricity system. Our results suggest that a CO2-BES facility can time shift electricity for durations up to multiple weeks and can increase the profit maximizing HVDC transmission capacity that connects a wind farm to a distant load center.

4 - Optimally Mining Heat for Geothermal Energy Production

Jonathan Ogland-Hand, Ohio State University, Columbus, OH, 43235, United States, Jeffrey M. Bielicki, Marcos Miranda, Thomas A. Buscheck, Kayyum Mansoor

Carbon dioxide (CO_2) may be more favorable than native geofluid as a geothermal heat extraction fluid due its higher mobility and the dynamics of a CO_2 plume in the subsurface. We developed and implemented a dynamic program of a natural resource economics approach for optimal heat mining and compared the use of water with the use of CO_2. Of the numerous results that are relevant for decarbonization, we find that CO_2 can be more cost-effective and more sustainably produce geothermal energy while also isolating CO_2 from the atmosphere to help mitigate climate change.

5 - Climate and Water Resource Impacts on Electricity Generation Systems in the United States

Ariel Miara, National Renewable Energy Laboratory, Golden, CO, United States

Power plants that require cooling provide 80% of electricity generation in the U.S. and rely on large volumes of water and sufficiently cool temperatures for optimal operations. This study evaluates the performance of 1,080 plants in the U.S. under future climates. Consideration of engineering interactions with climate, hydrology and environmental regulations reveals the need for regional adaptation strategies. Without placing climate-water impacts in a power systems context, assessments may misgauge the extent of vulnerabilities. Climate-water impacts may affect systems-level reliability, highlighting the need to integrate climate-water constraints into energy planning.

Sunday, 9:50AM - 10:50AM

■ Plenary

CC- Room 6E

Plenary: Seeking Perfection: Reflections on the Journey

Plenary Session

Introducers: Ramayya Kristnan & Archis Ghate

1 - Seeking Perfection: Reflections on the Journey

Gary S. Kaplan, Virginia Mason, Seattle, WA, United States

This session will review the Virginia Mason journey over 17 years to transform its organization and culture. From the early changes and challenges focused on old paradigms to the adoption of the Toyota Production System (Lean Management) as its management system, this session will highlight early resistance to change, the development of a new strategic plan, adoption of new compacts with physicians, leaders, and board members, and hard wiring improvements in quality and safety for sustainability. The session will include the critical role of leadership and governance and the implications of change in a very dynamic marketplace.

Sunday, 11:00AM - 12:30PM

■ SB01

CC- Room 201

Data Mining Best General Paper

Sponsored: Data Mining

Sponsored Session

Chair: Ali Dag, Vermillion, SD, 57069, United States

Co-Chair: Changqing Cheng, Binghamton University, Systems Science Industrial Engineering, Binghamton, NY, 13902, United States

Co-Chair: Evangelos Triantaphyllou, Louisiana State University, Division of Computer Science & Engineering, Baton Rouge, LA, 70803, United States

1 - Personalized Dynamic Pricing with Machine Learning: High Dimensional Features and Heterogeneous Elasticity

Gah-Yi Ban, London Business School, Regent's Park, London, NW1 4SA, United Kingdom, N. Bora Keskin

Motivated by online retail applications, we consider a seller who offers personalized prices to individual customers. The seller initially does not know the impact of individual customer characteristics on demand, but can learn about this relationship via sales observations. We construct and analyze near-optimal policies that balance the learn-and-earn tradeoff in this setting.

2 - Data Aggregation and Demand Prediction

Renyu Zhang, New York University, New York, NY, United States, Kevin Jiao, Maxime C. Cohen

Retailers collect large volumes of data to predict future demand for hundreds of products simultaneously. We propose a practical method - referred to as the Data Aggregation with Clustering (DAC) algorithm - that balances the tradeoff between data aggregation and model flexibility. The DAC allows us to predict demand while optimally identifying the features that should be estimated at the (i) item, (ii) cluster, and (iii) aggregated levels. We then show that the DAC has both theoretical and practical advantages.

3 - Probabilistic Structure Learning for EEG/MEG Source Imaging with Hierarchical Graph Prior

Feng Liu, MGH, Harvard Medical School, Massachusetts General Hospital, Boston, MA, United States, Li Wang, Yifei Lou, Ren-Cang Li, Patrick L. Purdon

Brain source imaging is an important method for noninvasively characterizing brain activity using Electroencephalogram (EEG) or Magnetoencephalography (MEG) recordings. Traditional EEG/MEG Source Imaging (ESI) methods usually assume that either source activity at different time points is unrelated, or that similar spatiotemporal patterns exist across an entire study period. The former assumption makes ESI analyses sensitive to noise, while the latter renders ESI analyses unable to account for time-varying patterns of activity. To effectively deal with noise while maintaining flexibility and continuity among brain activation patterns, we propose a novel probabilistic ESI model based on a hierarchical graph prior. Under our method, a spanning tree constraint ensures that activity patterns have spatiotemporal continuity. Comprehensive numerical studies using synthetic data on a real brain model are conducted under different levels of signal-to-noise ratio (SNR) from both sensor and source spaces. We also examine the EEG/MEG data under auditory and visual stimuli, in which our ESI reconstructions are neurologically plausible. Our method also shows accurate result for epilepsy patients. All the results demonstrate significant improvements of the proposed algorithm over the benchmark methods in terms of source localization performance, especially at high noise levels.

4 - Ranking Features to Promote Diversity: An Approach Based on Sparse Distance Correlation

Andi Wang, Georgia Institute of Technology, Atlanta, GA, 30318, United States, Juan Du, Jianjun Shi

Please check the mobile app or online for this abstract.

■ SB02

CC- Room 202

Fairness, Accountability, and Transparency in Machine Learning

Sponsored: Data Mining

Sponsored Session

Chair: Berk Ustun

1 - Fair Classification and Social Welfare

Lily Hu, Harvard University, Cambridge, MA, 02139, United States, lilyhu@g.harvard.edu, Yiling Chen

What is the relationship between fairness as defined by computer scientists and notions of social welfare? We present a welfare-based analysis of classification and fairness regimes. Our main findings center on sensitivity analyses of fairness-constrained risk minimization programs. We characterize the ranges of perturbations to a fairness parameter that yield better, worse, and neutral outcomes in utility for individuals and groups. We show that preferring "more fair" classifiers does not abide by the Pareto Principle—a fundamental axiom of social choice theory and welfare economics.

2 - Actionable Recourse in Linear Classification

Alexander Spangher, Stanford University, Menlo Park, CA, United States, alexander.spangher@gmail.com

Classification models are often used to make decisions that affect humans: whether to approve a loan, extend a job offer, or provide insurance. In such applications, individuals should have the ability to change the decision of the model. When a person is denied a loan by a credit scoring model, for example, they should know what changes to make to gain approval. Otherwise, this person will be denied the loan so long as the model is deployed, and, more importantly, will lack agency over a decision that affects their livelihood. We present a new way to audit linear classification models in terms of "recourse": the ability of a person to change the decision of the model through actionable input variables.

3 - Assessing Disparate Impact of Personalized Interventions: Identifiability and Bounds

Angela Zhou, Cornell University ORIE, Ithaca, NY, 14853, United States, Nathan Kallus

Personalized interventions in social services, education, and healthcare leverage individual-level causal effect predictions in order to prioritize program interventions for the individuals most likely to benefit. Actually auditing their disparate impacts per metrics such as true positive rates, is impossible since ground truths are unknown; nonetheless we can point-identify these quantities under the additional assumption of monotone treatment response and provide a sensitivity analysis for this assumption under violations of monotonicity of varying strengths. We illustrate auditing personalized interventions with ROC and xROC curves in a case study of a French job training dataset.

4 - Predictive Multiplicity in Classification

Charles Marx, Haverford College, Haverford, PA, United States, Flavio du Pin Calmon, Berk Ustun

Machine learning problems exhibit "multiplicity" when there exist several "good" models with near-optimal performance. In this talk, we discuss a specific kind of multiplicity — predictive multiplicity — which describes the existence of good models with conflicting predictions. We describe how predictive multiplicity arises in practice, and how it affects fairness and explain ability in human-facing applications such as recidivism prediction. We present formal measures of predictive multiplicity along with integer programming tools to compute these measures for linear classification problems.

■ SB03

CC- Room 203

Data Analytics in Complex Systems – Applications in Manufacturing

Sponsored: Data Mining

Sponsored Session

Chair: Cheng-Bang Chen

1 - Characterization of Fiber Orientation and Curvature Tensors in Carbon Fiber Reinforced Polymer Composite using Micro X-ray Computed Tomography

Shenli Pei, The Pennsylvania State University, State College, PA, United States, Kaifeng Wang, Jingjing Li

This study characterizes fiber orientation tensor and curvature tensor in injection-molded short- and continuous-carbon fiber reinforced polymer composites. The tensors are calculated from individual fibers extracted from 3D micro X-ray computed tomography images representing materials' interior microstructure. We propose a new fiber extraction algorithm, which consists of local 3D template matching and fiber orientation tracking for image segmentation and fiber reconstruction, respectively. The proposed algorithm is suitable for both short and continuous fibers, especially for regions with congested fibers.

2 - Heterogeneous Recurrence Analysis of Spatial Data with Applications in Manufacturing

Cheng-Bang Chen, The Pennsylvania State University, State College, PA, 16801, United States, czc184@psu.edu, Hui Yang, Soundar Kumara

To delineate the recurrence dynamics of the spatial data, prior efforts developed a hyper-dimensional recurrence plot or utilized the weighted network structure to characterize the spatial recurrence patterns. However, these works treated all recurrences homogeneously that rich information embedded on the heterogeneous states are not fully explored in the spatial domain. We propose a novel approach utilizing the space-filling curve and fractal representation to quantify the heterogeneous recurrences of the spatial data. Experimental results show our approach yields superior performance in the extraction of salient features to characterize recurrence dynamics in spatial systems.

3 - Predictive Analytics in Automobile Manufacturing with Bag-of-Words and Multivariate Time Series Classification

Shenghan Guo, Rutgers University, Piscataway, NJ, 08854, United States, sg888@scarletmail.rutgers.edu

In advanced manufacturing, data are collected from multiple sensors during the manufacturing process, resulting in multivariate time series (MTS) data. Fault prediction for manufacturing process based on MTS is challenging due to the high dimensionality and potential dependency among attributes. In addition, patterns that are highly relevant to fault occurrence may be hidden behind the complexity of MTS. Bag-of-Words models extract features by converting numerical observations into sets of words (features). Pattern recognition and dimensionality reduction are thus achieved by feature selection. MTS classification is then applied to the selected features for predicting failure events.

4 - A Deep Learning Approach for Sensor-based Monitoring of Transient Processes: A Study Case for Characterizations of Machining Natural Fiber Reinforced Plastics

Zimo Wang, Texas A&M University, College Station, TX, 77840, United States

We investigated a long short-term memory (LSTM) recurrent neural network to relate the waveform features of transient acoustic emission (AE) sensor signals to different process conditions and the underlying material removal mechanisms during machining natural fiber reinforced plastics (NFRP). The developed model is tested on the AE data gathered from earlier conducted orthogonal cutting experiments on NRFPs samples with various cutting speeds and fiber orientations. Results from this experimental study suggest that the employed recurrent neural network can correctly predict (over 88% accuracy) the cutting conditions based on the extracted temporal-spectral features of AE signals.

■ SB04

CC- Room 204

Statistical Learning for Complex Data

Sponsored: Data Mining

Sponsored Session

Chair: Qiong Zhang

Co-Chair: Christopher McMahan, Clemson University, Clemson, SC, United States

1 - An Additive Regression Model for Group Testing Data

Christopher McMahan, Clemson University, Clemson, SC, United States, mcmaha2@clemson.edu, Yan Liu, Joshua Tebbs, Christopher Bilder

Group testing has proven to be a cost-effective alternative to one-at-a-time testing. Several authors have developed regression methods to analyze group testing data but generally proceed under the assumption that covariate effects are linear. To avoid the potential pitfall of this assumption, we propose a Bayesian generalized additive model to describe the individual-level probability of disease with potentially misclassified group testing data. This model can be used to analyze data arising from any group testing protocol with the goal of estimating multiple unknown smooth functions of covariates, standard linear effects for other covariates, and even assay accuracy probabilities.

2 - Multi-resolution Functional ANOVA for Large-scale, Many-input Computer Experiments

Chih-Li Sung, Michigan State University, East Lansing, MI, 48824, United States, sungchih@msu.edu

The Gaussian process is a standard tool for building emulators for both deterministic and stochastic computer experiments. However, application of Gaussian process models is greatly limited in practice, particularly for large-scale and many-input computer experiments that have become typical. In this talk, a multi-resolution functional ANOVA model will be introduced as a computationally feasible emulation alternative. More generally, this model can be used for large-scale and many-input non-linear regression problems.

3 - Modeling of System Internal State Degradation from Sensor Monitoring Data and Engineering Physics

Mohammadmahdi Hajiha, University of Arkansas, Fayetteville, AR, 72701, United States, mhajiha@email.uark.edu, Xiao Liu

Based on the thermodynamic law that governs the relationship between system internal states, operating conditions and cooling efficiency, a physics-based statistical approach for modeling the cooling efficiency is proposed. The model also takes into account the statistical dependence among system state variables and captures the complex dependence structure by the Archimedean family of copulas with its generator function approximated by cubic B-splines.

■ SB05

CC- Room 205

Recent Advances of Practical Data Mining Techniques in Transportation Planning with Emphasis on Supply Chain Networks Supported by Machine Learning

Sponsored: Data Mining

Sponsored Session

Chair: Muhannad H. Ramahi, TTX Company, Chicago, IL, United States

1 - Data Mining to Improve Transit Performance and Better Inform Transit Riders

Brian Mayer, Research Associate, Virginia Polytechnic Institute and State University, Blacksburg, VA, 24060, United States, bmayer@cs.vt.edu, Nikhil Muralidhar, Naren Ramakrishnan

It is projected that by the year 2030, 6 out of 10 people will live in a city and transportation is a key issue concerning urban populations. In the United States the average commute time is 52 minutes and the average urban commuter spends 42 hours sitting in traffic each year. The Washington Metropolitan Area Transit Authority is working with the NSF-sponsored Urban Computing Program at Virginia Tech to use data mining to solve real-world problems enabling WMATA to improve performance and better inform riders. The team has used passenger tap-in/out, train movement, & bus location data to cluster stations/users, make predictions of future demand & performance, and identify delay patterns.

2 - Rail Routing and Travel Times in a Congested North American Network

Andrzej Zuranski, Princeton Consultants Inc., Princeton, NJ, United States, azuranski@princeton.com

A study is performed on measuring travel times for a North American rail network using a one-year data sample for a fleet of automotive railcars. We present a method of route segmentation based on railcar location reports when missing data and out-of-time data is common using a directed graph. We then study historical travel times on each viable route segment and its dependence on local railcar congestion using a handful of data mining techniques based on temporal or global correlations. Finally, an ETA model is constructed, and its precision is evaluated.

3 - A Comparative Study between Machine Learning and Classical Methods in Forecasting Railroad Operational Metrics

Muhannad H. Ramahi, TT X. Company, Chicago, IL, 60606, United States, Muhannad.Ramahi@TTX.com

A comparative study between machine Learning and Classical Methods in Forecasting Railroad Operational Metrics We present a study/results of exploring a new technique for forecasting railroad operational metric(s) such as cycle time and railcars network mileage. The goal is to explore the new emerging techniques of machine learning against classical methods in predicting cycle time and railcar mileage for various fleets. Cycle time is an essential part of the business planning process that partly determines how many railcars are potentially needed for satisfying the network demand. Moreover, mileage prediction is critical in deciding how equipment maintenance is planned and budgeted.

4 - Big Data for Smart Rail

Kristina Chambers, Director Operations Strategy and Analytics, TTX. Company, Chicago, IL, 60606, United States, Kristina.Chambers@TTX.com

TTX Company is applying innovative data science solutions to railcar maintenance for their fleet of 220k railcars. They are developing machine learning models and advanced analytics techniques to tackle tough business challenges, automate processes and drive business value across the organization. This presentation will provide an introductory overview of machine learning and provide a foundational context for how the data science work at TTX has helped them evolve their business processes and enhance decision making.

■ SB06

CC- Room 209

Joint Session DM/Practice Curated: Biases in Data Mining, the Achilles' Heel of Intelligent Machines

Sponsored: Data Mining

Sponsored Session

Chair: Bridget Huang, APKUDO

1 - Designing Bias-free, Generic Number Guessing Games that Mimic the Stock Market and Eliminate Non-randomness

Vincent Granville, Co-founder, Data Science Central, Issaquah, WA, United States, vincentg@datasciencecentral.com

We discuss a generic number guessing game, mimicking stock trading or a lottery, depending on the model parameters. A public algorithm is available to compute the winning numbers in advance, based on chaotic but ergodic sequences. The gain and losses are known in advance and pre-recorded in public ROI tables. The player can design her own ROI table, with the expected average return set to some pre-specified level (typically 0% for a fair game) and pre-specified maximum cap for the volatility, in order for the operator to control cash float. Biases can be introduced in the system, accidentally or on purpose. We discuss these types of biases, and how to address them.

2 - Democratizing Data Science

Brian Wright, Co-Director, Data Science Graduate Programs GW, George Washington University, 1556 Westmoreland St., Washington, DC, 22101, United States, bwright.wright6@gmail.com

The expansion of AI into everyday life brings with it the unanticipated challenge of confronting decisions or recommendations that could be considered bias or even unethical. Technical approaches to combat algorithmic bias have been advancing in recent years and show great promise, however, these solutions can only partly address the problem. Research shows that increases in general knowledge related to AI systems actually reduces trust. I'll discuss how this distrust could be healthy, that the nature of the field of data science works in our favor and ways that we can facilitate broader awareness to elicit increased discourse and allow for a "healthy distrust" of AI.

3 - Handling Classification Bias in Tagging Medical IoT Devices with Token Data

Richard Xie

Please check the mobile app for this abstract.

4 - Privacy Protection vs. Prevention of Biases in Telecom Industry Data Virgin Territories Exploration

Hongyi Bridget Huang, APKUDO, Baltimore, MD, United States, huang1225@hotmail.com

In the era of customized services, no one expects it haunts the public with data privacy invasion. With regulations like GDPR, the public pay attention to their privacy, which increases the tendency of data missing. Considering the real-world data is not perfect, will the new trend jeopardizes the data quality by introducing more biases? The telecom industry Exchange Risk Index optimizes the devices exchange process. It gives the utility to estimate the performance of any issue. It also enables prioritizing the concerned issues and predicting the future risk performance. Exchange consists of individual behaviors. Each data point is critical. How to adjust the data operation strategies to the new norm?

5 - A New Fairness Improvement Approach in Incentive Structure Optimization for Uber Vehicle Solution

Le Li, Data Science Manager, Uber, Seattle, WA, United States, Shitao Wang

Uber Vehicle Solution program is an important global force in Uber ride-sharing business, and it provides end to end vehicle services to drivers who are willing to drive for Uber but do not have vehicle access. Vehicle solution mainly operates in vehicle-constrained markets. Increasing vehicle utilization is one of the key initiatives to drive supply in those areas. Comparing with traditional driver-based incentive, the vehicle-based incentive aims to increase vehicle sharing and drives vehicle-based utilization higher. The vehicle-based incentive is proved to be the most economical way to increase vehicle utilization, which improves earnings per vehicle - with little diminishing return.

■ SB07

CC- Room 210

Joint Session DM/Practice Curated: Predictive and Prescriptive Analytics for Hospital Command Centers

Sponsored: Data Mining

Sponsored Session

Chair: Bex Thomas

1 - Diagnostic, Predictive and Prescriptive Analytics for Hospital Operations and Clinical Care

Bex George Thomas, GE Healthcare, San Ramon, CA, 94583-9130, United States

Please check the mobile app for this abstract.

2 - Dynamic Machine Learning Models to Improve Patient Care in PERIOP

Kevin Yang, General Electric Healthcare, Hoffman Estates, IL, United States, Kevin.Yang@ge.com

In the industry of healthcare, quality and efficiency of services are always the focus of attention of service providers and patients. There are various reasons that a delay occurs during the pipeline of a surgical operation. This presentation illustrates a deployment of machine learning methods to predict the possibility that a delay will happen during the workflow. Therefore, the service providers will have opportunities to improve their efficiency and satisfy their patients ultimately.

3 - A Multi-layer Prescriptive Analytic for Efficient Workforce Deployment and Planning for Hospital Machine Maintenance and Repairs

Thanos Aristotelis, General Electric Global Research, Niskayuna, NY, United States, a.thanos@ge.com

GE Healthcare manages several thousand Field Engineers (FEs) over a 5000-hospital customer base, serving approximately 70,000 devices under specific contractual service level agreements. The FEs are responsible to provide phone support, perform preventative maintenance and conduct on-site repair for unexpected machine failure. The customers-hospitals depend on the timely and efficient repair and maintenance of those devices to provide in turn high quality healthcare services. To achieve this goal we have designed and implemented a multi-layer prescriptive analytic that targets to provide decision support on hiring, training, assigning shifts and scheduling the repairs.

■ SB08

CC- Room 211

Joint Session AI ML/ICS: Machine Learning Meets Discrete Optimization

Emerging Topic: Artificial Intelligence & Machine Learning

Emerging Topic Session

Chair: Thiago Serra, Bucknell University, Mitsubishi Electric Research Labs, Lewisburg, PA, 02139, United States

1 - A Sample Size-Efficient Polyhedral Encoding and Algorithm for Deep Neural Network Training Problems

Gonzalo Muñoz, Polytechnique Montreal, 2920 Chemin de la Tour, Montreal, QC, H3T 1N8, Canada, gonzalo.munoz@polymtl.ca, Daniel Bienstock, Sebastian Pokutta

Deep Learning has received much attention lately, however, results regarding the computational complexity of training deep neural networks have only recently been obtained. Moreover, all current training algorithms for DNNs with optimality guarantees possess a poor dependency on the sample size, which is typically the largest parameter. In this work, we show that the training problems of large classes of deep neural networks with various architectures admit a polyhedral representation whose size is linear in the sample size. This provides the first theoretical training algorithm with provable worst-case optimality guarantees whose running time is polynomial in the size of the sample.

2 - Optimizing Over Trained Neural Networks

Christian Tjandraatmadja, Google Research, Cambridge, MA, United States, Ross Anderson, Joey Huchette, Will Ma, Juan Pablo Vielma

We present an overview of tf.opt, a MIP-based solver for optimization models embedded with neural networks. Its goal is to find decisions x that optimize f(x) under constraints, where f(x) is given by a trained neural network with a piecewise linear architecture. This problem appears in a variety of areas, such as deep reinforcement learning, sequence design, and neural network verification. Our solver inherits two advantages from MIP: optimality guarantees, useful for verifying neural network properties, and mixed-integer linear constraints, which pave the way to large combinatorial action spaces in deep reinforcement learning. We discuss these applications and the techniques within tf.opt.

3 - Strong Mixed-integer Programming Formulations for Trained Neural Networks

Joey Huchette, Rice University, Houston, TX, 02143, United States, Ross Anderson, Will Ma, Christian Tjandraatmadja, Juan Pablo Vielma

We present strong mixed-integer programming (MIP) formulations for high-dimensional piecewise linear functions that correspond to trained neural networks. These formulations can be used for a number of important tasks, including robustness verification, or "predict, then optimize" decision problems with machine learning models embedded inside. We derive MIP formulations a number of the most popular nonlinear operations (e.g. ReLU and max pooling) that are strictly stronger than other approaches from the literature. We corroborate this computationally, showing that our formulations are able to offer substantial improvements in solve time on image classification verification problems.

4 - Exact and Approximate Transformations of Deep Neural Networks

Thiago Serra, Bucknell University, Lewisburg, PA, 02139, United States, Abhinav Kumar, Srikumar Ramalingam

We study the possibility of transforming a deep neural network to another network with a different number of units or layers, which can be equivalent or an approximation. First, we show that certain rectified linear units (ReLUs) can be safely removed from a network if they are always active or inactive for any valid input. Second, we show that any feed-forward ReLU network can be approximated to arbitrary precision by a 2-hidden layer shallow network with a fixed number of units associated with the linear regions of the original network. Based on experiments with ReLU networks on the MNIST dataset, we found that networks trained with L1-regularization can be effectively compressed due to weight sparsity.

■ SB09

CC- Room 212

AI-powered Supply Chain Management

Sponsored: Artificial Intelligence

Sponsored Session

Chair: Junming Liu, Rutgers Business School, Newark, NJ, 07102, United States

1 - Enhancing Recommender System for Taxi Drivers with Business Effective Strategies

Mingfei Teng, Rutgers Business School, Newark, NJ, 07102, United States, mingfei.teng@rutgers.edu

We propose an enhanced recommender system aiming to maximize the expected profit of the taxi drivers. Specifically the system estimates the pickup probability for each road segment. Followed by the estimation, it makes an optimization-based decision whether to take the best route given by our route searching strategy or waiting at a specific virtual station which is identified by the virtual station discovery procedures based on taxis' trajectory data. Finally, we carry out extensive experiments on a real-world data set and the experimental results clearly validate the effectiveness of the proposed system.

2 - Operational Values of AI-powered Demand Forecasting for Fast Fashion Products

Jingci Ming, Rutgers University Business School, Newark, NJ, United States, jingci.ming@rutgers.edu

The store-level product demand forecasting is of great importance for the daily operations of fast-fashion retailers. We propose a demand forecasting model with Seq2Seq concerning specific information including store environmental information and life cycle of categories of SKUs. We develop our model with the collaboration with a leading fast-fashion company. By comparing with other baseline models we significantly improve the prediction accuracy which contributes to the daily inventory control.

3 - An Iterative Algorithm for Multi-level E-logistics Distribution Center Network Design

Jingyuan Yang, Assistant Professor, George Mason University, Fairfax, VA, 22030, United States, jyang53@gmu.edu, Junming Liu

The multi-level distribution center (MLDC) network, aiming to provide a fast and reliable logistic service for product shipment and delivery, is becoming critical for online retailers. The location selection of this MLDCs for fast delivery and low logistics cost remains a challenging task due to two problems: a) how to accurately predict the customer demand distribution in a new DC network; b) how to effectively solve the large-scale MLDC site location selection problem given the sales distributions. We propose an iterative hierarchical optimization strategy for multi-level inter-connected DC network site selection.

4 - An Intelligent Production-distribution System for Perishable Products

Junming Liu, City University of Hong Kong, Hong Kong, 07102, Hong Kong, junmiliu@cityu.edu.hk, Yijun Wang

We develop a data-driven intelligent production-distribution system for perishable product retailers, aiming to minimize the long-term profit loss due to the stockouts and overstock. By collaborating with a leading perishable product retailer, we combine the detailed internal supply chain data and environmental factors. The system consists of two modules: an L-day ahead sales demand forecasting model based on a seq2seq deep learning model with store aggregation and environmental semantics, and 1-day ahead multi-product redistribution. We validate the system performance by comparing the profit loss with other baselines and the current system in the perishable product industry.

■ SB10

CC- Room 213

Experts, Opinions, and Forecasts

General Session

Chair: Jason R.W. Merrick, Virginia Commonwealth University, Richmond, VA, 23284, United States

Co-Chair: Yael Grushka-Cockayne, Harvard Business School, Boston, MA, 02163, United States

1 - Using Prediction Interval Skewness to Improve Forecast Accuracy

Yael Grushka-Cockayne, Harvard Business School, Boston, MA, United States, ygrushkacockayne@hbs.edu, Victor Jose, Jacob Rittich, Jack Soll

We examine how accuracy of the aggregate forecast can be improved when prediction intervals are considered. We show how implied skewness from the three elicited points can be used to combine forecasts. We propose an aggregation method that incorporate skewness to asymmetrically trim forecasts and study properties of this method on two data sets.

2 - Expert Selection Within a Single Judgment Problem

Asa Palley, Indiana University, Bloomington, IN, 47405, United States, Ville Satopaa, Jack Soll

Averaging point estimates from a select set of judges can provide a more accurate consensus estimate. We develop methodology to identify a high-performing set of judges within a single estimation task, without relying on past performance data. Judges' predictions of others are used as part of a customized criterion to identify this select crowd. The procedure identifies a set of judges who collectively hold a list of point estimates which happen to be accurate when averaged. In theory, our proposed aggregation procedure can extract the most accurate information from the crowd and provide a consensus estimate with greater accuracy than previously proposed methods.

3 - Forecast Combination with Multiple Models and Expert Correlations

Jason R. W. Merrick, Virginia Commonwealth University, Richmond, VA, 23284, United States, David Soule, Yael Grushka-Cockayne

A simple average of forecasts has been found to be robust despite theoretically superior combination methods. This is known as the forecast combination puzzle. We study the role of number of experts and expert correlation levels on the distribution of estimated weights and propose a new combination heuristic which reduces the impact of correlation estimation errors. This heuristic is shown to outperform a simple average on economic and experimental data.

■ SB11

CC- Room 214

Social Media Analytics Methods, Tools and Platforms

Sponsored: Social Media Analytics

Sponsored Session

Chair: Tung Cu, Bloomsburg University of Pennsylvania, PA, United States

1 - Pricing the Cloud: A QoS-based Decentralized Auction Platform

Yang Lu, PhD, Old Dominion University, Norfolk, VA, 29466, United States, ziiyuu@gmail.com

Cloud computing, providing computing resources as services, will have a major impact on the IT industry. How to price and allocate cloud resources to meet users' requirements is an important problem in both IT and business disciplines. Inspired from blockchain and economics, this study proposes a hybrid decentralized trading platform based on cloud QoS (Quality of Service). In this approach, cloud consumers place a bid on the computing resources based on the QoS preferences. An integration of QoS and blockchain technologies, enabling each user to invest and manage cloud resources.

2 - What YouTube Videos Really Tell You: Identity Economics Perspective

Jae Hoon Choi, University of Wisconsin Green Bay, Green Bay, WI, United States

Economics is not only about money, today. Noneconomic motives need to be studied as well. People behave based on the beliefs about who they are, and how they are supposed to behave, in every social context. Economic outcomes are established not only by pecuniary motives, but also by people's identities. YouTube is one of the most widely used platforms which allows users to share user-generated videos. It also allows users to add comments on those videos. This paper investigates a framework for incorporating social identities into standard economics models using YouTube content. This paper examines the effect of social identities, focusing on gender identity and ethnic identity, on economic behaviors.

3 - Comment Symbols: How Do You Deal with Them?

Tung Cu, Northeastern Illinois University, Chicago, IL, 17815, United States, Charletta F. Gutierrez

The study investigates how people use symbols embedded in comments as a community language to express their idea, attitude and perception to a certain topic. To this end, a research method is conducted to survey online members of common social media networking sites. The results show that while textual comments might expose user's sentiment, symbols not only exaggerate or reverse the comment meaning, but also reflect a new kind of linguistic gesture in online settings. The study offers some discussions and recommendations for business managers who want to better understand their customers.

4 - Modeling and Visualizing the Effects of Educational Advertising on Disengaged Hispanic Americans

Olivia Hernandez, Ohio State University, Columbus, OH, United States

Voter turnout among Hispanic Americans is low and falling. We study knowledge levels about major public policy facts among Hispanics and the empirical effects of educational advertising campaigns. Several visualizations are provided that indicate the scope of related challenges and the promise of outreach efforts for improving knowledge and attitudes.

5 - Investigation of Cookie Vulnerabilties

Marjani Peterson, Hampton University, Hampton, VA, 23669, United States, marjani.peterson@my.hamptonu.edu, Chutima Boonthum-Denecke

Cookies have emerged as one of the most convenient solutions to keep track of browsers. They continue to raise both security and privacy concerns due to their continuous evolution. There is limited support for confidentiality, integrity, and authentication in the way cookies are used. In this respect, the possibilities for misusing cookies are very real and are being exploited. Commonly used browsers have the ability to enable or disable cookies, or prompt the client to accept the cookies, or not. This paper will discuss the pros and cons of cookies as well as preferences of users based on survey results. This paper will discuss cookie vulnerabilities, ways to exploit them, and ways to mitigate them.

■ SB12

CC- Room 2A

Information, Learning and Dynamic Resource Allocation

Sponsored: Applied Probability

Sponsored Session

Chair: Kuang Xu, Stanford Graduate School of Business, Stanford, CA, 94305, United States

1 - Kingman's Transform Method for Heavy-traffic Queues

Johan van Leeuwaarden, Eindhoven University of Technology, Eindhoven, Netherlands, j.s.h.v.leeuwaarden@TUE.nl

Heavy traffic limit theory deals with queues that operate close to criticality and face severe wait. Let W denote the stationary waiting time in the GI/G/1 queue. Kingman (1961) showed that an appropriately scaled W converges in distribution to an exponential random variable, as the queue approaches criticality. The original 1961 proof of this famous result uses the transform method, showing convergence of transforms, and hence weak convergence of the associated random variables. We apply and extend this transform method to obtain convergence of moments and refined approximations. We also demonstrate how the transform method can be applied to other heavy-traffic regimes and other queueing models.

2 - On the Learning Benefits of Resource Flexibility

Mihalis Markakis, IESE Business School, Avenida Pearson, 21, North Campus, T-402, Barcelona, 08034, Spain

Resource flexibility is known to provide firms facing demand uncertainty with such benefits as risk pooling, revenue-maximization optionality, and operational hedging. In this article we uncover a heretofore unknown benefit: we establish that resource flexibility mitigates censoring of sales data, and thereby facilitates learning the true demand under a variety of practical settings and demand distributions. Further, we quantify these learning benefits of flexibility and find them to be of the same order of magnitude as the extensively studied risk pooling benefits of flexibility.

3 - Deep Exploration in Reinforcement Learning via Randomized Value Functions

Daniel Russo, Columbia University, Kellogg School of Management, New York, NY, 60208, United States

We propose the use of randomized value functions to guide systematic exploration in reinforcement learning. This offers an elegant means for synthesizing statistically and computationally efficient exploration with common RL algorithms like temporal-difference learning, which produce parameterized value function estimates. We present several RL algorithms that leverage randomized value functions and demonstrate their efficacy through computational studies. I'll also discuss a new worst-case regret bound for these methods that establishes statistical efficiency with a tabular representation.

4 - Experimenting in Equilibrium

Stefan Wager, Stanford GSB, 655 Knight Way, Stanford, CA, 94305, United States

We study experimental design in large-scale stochastic systems with substantial uncertainty and structured cross-unit interference. We consider the problem of a platform that seeks to optimize supply-side payments p in a centralized marketplace where different suppliers interact via their effects on the overall supply-demand equilibrium and propose a class of local experimentation schemes that can be used to optimize these payments without perturbing the overall market equilibrium.

■ SB13

CC- Room 2B

Markets and Equilibria I

Sponsored: Applied Probability

Sponsored Session

Chair: Krishnamurthy Iyer, University of Minnesota, United States, kriyer@umn.edu

1 - Mean Field Equilibrium: Uniqueness, Existence, and Comparative Statics

Bar Light, Stanford, Stanford, Stanford, CA, United States, Gabriel Weintraub

The standard solution concept for stochastic games is Markov perfect equilibrium (MPE); however, its computation becomes intractable as the number of players increases. Instead, we consider mean field equilibrium (MFE) that has been popularized in the recent literature. MFE takes advantage of averaging effects in models with a large number of agents. We make three main contributions. First, our main result in the paper provides conditions that ensure the uniqueness of an MFE. Second, we generalize previous MFE existence results. Third, we provide general comparative statics results. We apply our results to dynamic oligopoly models commonly used in previous work.

2 - Near Optimal Control of a Ride-hailing Platform via Mirror Backpressure

Pengyu Qian, Columbia University-Graduate School of Business, Columbia Business School, New York, NY, 10027, United States, PQian20@gsb.columbia.edu, Yash Kanoria

Ride-hailing platforms need to match supply and demand so as to maximize payoff under the geographical flow constraints. We consider two platform control settings: joint entry-assignment (JEA) and joint pricing-assignment (JPA). We introduce a novel family of Mirror Backpressure (MBP) policies which are simple, practical, and do not require knowledge of the demand arrival rates. MBP generalizes Backpressure policy such that it executes mirror descent. MBP loses at most $O(K/T + 1/K)$ fraction of the achievable payoff in JEA and $O(\sqrt{(K/T + 1/K)})$ fraction in JPA, where K is the number of vehicles and T is the horizon. Simulation results in a realistic environment support our theoretical findings.

3 - Matching Supply and Demand with Mismatch-Sensitive Players

Mingliu Chen, Duke University, Durham, NC, 27560, United States, mingliu.chen@duke.edu

We study a matching problem using a novel method to characterize the mismatch. In particular, players' preferences are uniformly distributed on a circle so the mismatch between two players is characterized by the one-dimensional circular angle between them. This framework allows us to capture matching processes in applications ranging from ride sharing to job hunting. We provide an analytical framework for analyzing the matching model based on a limiting regime where overall customer arrival rates are high, and players demonstrate low tolerance towards mismatch. Our analysis reveals meaningful insights on market and matching design.

4 - Scrip Economies are Fair and Efficient

Artur Gorokh, Cornell University, Ithaca, NY, United States

We consider the problem of allocating multiple items dynamically between several agents without money, where the preferences of participants are fractionally subadditive (XOR), random and independent both in time and across agents. We investigate the properties of a particular simple mechanism: endowing participants with budgets of artificial currency and repeatedly running simultaneous first price auctions. In particular, we show that this mechanism can be viewed as approximately implementing Kalai-Smorodinsky bargaining outcome, as maxmin value of each agent is a 1/2 approximation of the ideal point of each agent.

■ SB14

CC- Room 302

Pricing Strategy and Games

Sponsored: Manufacturing & Service Oper Mgmt

Sponsored Session

Chair: Li Chen, Cornell University, Ithaca, NY, 14853, United States

Co-Chair: Yao Cui, Cornell University, Ithaca, NY, 14853, United States

1 - Bundle Pricing of Congested Services

Chenguang (Allen) Wu, Hong Kong University of Science and Technology, HongKong University of Science and Technology, Clear Water Bay, 60208, Hong Kong, allenwu@ust.hk, Luyi Yang

Bundle pricing is commonly adopted by service firms managing multiple congestion-prone service facilities. Under bundle pricing, the firm charges a single price for all the services as a whole, and customers either purchase the bundle or do not purchase at all. This scheme is in contrast to a la carte pricing, under which the firm sets a separate price for each service, and customers can choose which service to purchase, if any. We explain when and how the prescriptive guidelines from the existing theory of bundling can be reversed in congested service settings.

2 - The Effect of Service Capacity on Price Competition and Customer Retention

Junhyun Bae, Cornell University, Ithaca, NY, 14850, United States, jb2258@cornell.edu, Li Chen, Yao Cui

We consider price competition between two firms who face a service capacity constraint in a market with experience-based customer switching cost. In our model, customers' purchase choices depend not only on price but also on service experience. We find that under-capacity mitigates price competition because customers are less likely to be locked in on either side. We also show that price decisions for both firms can be randomized when their capacity covers slightly less than the full market or slightly more than the full market. Our paper could explain a business phenomenon of active price promotion strategies in practice through the lens of operational/marketing frameworks combined.

3 - Not Every Game is Created Equal: The Impact of Variable Pricing on NFL Ticket Markets

Ovunc Yilmaz, University of Notre Dame, South Bend, IN, 46617, United States, oyilmaz@nd.edu, Alper Arslan, Necati Tereyagoglu

Although variable pricing is recommended to event organizers to respond to changing popularity across their events, the evidence documenting its impact on capacity utilization is much less present in the empirical revenue management literature. In this study, we study the effect of adopting variable pricing strategies on primary market sales using Difference in Differences approach on quasi-experimental data from the NFL. We elaborate on the mechanism behind the benefits of variable pricing by checking its implications on the resale market prices and volume.

4 - Bonus Competition in the Gig Economy

Xiaoyan Liu, Cornell University, Ithaca, NY, 14853, United States, Yao Cui, Li Chen

Service platforms in the gig economy commonly offer bonuses to independent service providers contingent on consistent participation. This paper studies the driving forces and implications of this bonus strategy. We analyze a model of two-sided platform competition in multi-periods. We find that platforms offer bonuses (i) when providers' willingness to participate is high and preference stickiness is low; (ii) when providers' willingness to participate is low. Platforms' bonuses are driven by their poaching incentives in case (i) and market expansion incentives in case (ii). Platforms will reduce bonuses under coordination, which improves platform profits and may not hurt social welfare.

5 - Optimal Design of the Platforms: Consumer Privacy Considerations

Ruslan Momot, Assistant Professor, HEC Paris, 78350, France, momot@hec.fr, Itay P. Fainmesser, Andrea Galeotti

We study an optimal design of a platform, users of which are concerned about their privacy. We build a stylized game-theoretic model in which users (i) experience direct utility from using the platform but also (ii) are susceptible to misuse of the information they reveal to the platform. The platform optimally chooses the information storage strategy and security level against user data leakage/misuse. We characterize optimal designs for the platforms of different types and derive corresponding levels of user activity and privacy.

■ SB15

CC- Room 303

Responsible Research in OM

Sponsored: Manufacturing & Service Oper Mgmt

Sponsored Session

Chair: Christopher S Tang, University of California-Los Angeles, Los Angeles, CA, 90095-1481, United States

1 - Gender-based Operational Issues Arising from On-demand Ride-hailing Platforms: Safety Concerns, Service Systems, and Pricing and Wage Policy

Yulan Wang, Hong Kong Polytechnic University, Hong Kong, yulan.wang@polyu.edu.hk, Pengfei Guo, Christopher S. Tang, Yanli Tang

Motivated by the recent development of women only ride-hailing platforms that aim to address the safety concerns raised by female riders and drivers, we examine whether a platform such as Didi should offer gender-specific services instead of the current gender-neutral services. We make an initial attempt to examine if and when gender-specific services can enable the platform to address female safety concerns and improve its profitability. We pinpoint that a key obstacle for the platform to move to the dedicated system is the limited female labor size. The equal policy under which the platform has to impose the same price and wage on both the female and male subsystems further burdens the platform.

2 - Improving Rehab Bus Services in Hong Kong

Lucas P. Veelenturf, Eindhoven University of Technology, Eindhoven, Netherlands, l.p.veelenturf@tue.nl, Christopher S. Tang

Armed with 164 mini-buses, Rehabus offers a non-profit public service in Hong Kong that is affordable and welcome by persons with disabilities (PWDs) for their daily commuting trips to work or school. Currently, the demand far exceeds the supply. Some PWDs have been on the waiting list for years. In this research we investigate how Rehabus can serve more passengers without increasing the number of buses and drivers and without increasing the waiting and travel time of passengers too much. Several complicated real-life operational constraints which needs to be considered make this a challenging task, e.g. the capacity of the bus is twofold (wheelchair and regular places) and even flexible.

3 - Environmental Violations in China: Evaluation of Long-term Impact and Prediction of Future Violations

Chris K. Y. Lo, Hong Kong Polytechnic University, Hong Kong, Hong Kong, kwan.yu.lo@polyu.edu.hk, Christopher S. Tang, Paul Zhou

We take a business analytic approach to examine ways to reduce irresponsible environmental violations of Chinese manufacturers. First, we perform a descriptive analysis to examine the long-term impact of 1542 environmental incidents on a firm's Returns on Assets and other operational performance indicators and we found significant negative impacts in consecutive years "only after" the violations were exposed. We then develop a prediction model that exposes over 71% of the violations by inspecting only 21.5% of the firms with top 80 percentile in risk scores. We finally present a prescriptive inspection mechanism to promote responsible operations in global supply chain.

4 - Improving Consumer Welfare and Manufacturer Profit via Government Subsidy Programs: Subsidizing Consumers or Manufacturers?

Joey Jiayi Yu, PhD, Tsinghua University, Beijing, China, University of California, Berkeley, Berkeley, CA, United States

Most consumers in rural areas of many developing countries cannot afford to purchase certain livelihood improvement products such as home appliances. To improve consumer welfare and manufacturer profit, many governments launch different types of subsidy programs that offer subsidies to consumers, manufacturers, or both. Motivated by a subsidy program developed by the Chinese government in 2007, we present a parsimonious model to determine the optimal subsidy program in different settings so as to gain a better understanding about the conditions under which it is optimal for the government to subsidize consumers only, manufacturers only, or both.

■ SB16

CC- Room 304

Learning and Incentives on Platforms

Sponsored: Manufacturing & Service Oper. Mgmt/Service Operations

Sponsored Session

Chair: Kenneth Moon, University of Pennsylvania, Philadelphia, PA, 19104, United States

Co-Chair: Hamsa Sridhar Bastani, Wharton School, Philadelphia, PA, 19104, United States

1 - Assortment Optimization for Online Marketplaces

Antoine Desir, INSEAD, Paris, 75011, France, antoine.desir@insead.edu, Santiago Balseiro

We consider the assortment optimization problem faced by a platform (such as Amazon or Google Shopping) connecting sellers and consumers when sellers have private information about the products they sell. We design tractable mechanisms for the platform that truthfully elicit the sellers' private information while taking into account the externalities among displayed sellers in the assortment. In doing so, our work combines ideas from mechanism design with interdependent values and assortment optimization.

2 - Information Acquisition Costs in Matching Markets

Irene Lo, Stanford University, Palo Alto, CA, 94306, United States

The design of centralized matching markets often assumes that agents know their preferences. We provide a model of many-to-one matching in college admissions that formally accounts for information acquisition costs in preference formation and captures students' disutility from providing full preferences ex ante. Our main finding is that standard matching mechanisms are susceptible to reaching information deadlocks, where no information is acquired because every agent needs more information to know how to get information. Instead we emphasize the importance of additional sources of aggregate market information and provide simple mechanisms that implement approximately optimal outcomes.

3 - Dynamic Pricing with Unknown Non-parametric Demand and Limited Price Changes

Divya Singhvi, Massachusetts Institute of Technology, Cambridge, MA, United States, Georgia Perakis

We consider a dynamic pricing problem where the retailer has no knowledge of the demand curve and there is a cost on price experimentation. The retailer seeks to efficiently learn the demand curve and keep the cost of price experimentation low. We propose an optimistic-pessimistic approach for price experimenting and learning which is simple and mimics industry practice. We provide revenue regret and price change bounds that are near optimal. We also perform numerical simulations to show considerable improvements over other pricing methods.

4 - Optimizing Services in Retail Networks

Amandeep Singh, The Wharton School, Philadelphia, PA, 19104, United States, amansin@wharton.upenn.edu, Kenneth Moon, Gad Allon

We study how retail stores' multi-dimensioned service levels affect consumers' buying behavior in spatial markets. To this end, we propose the Double Block-Lasso BLP estimator under mild assumptions of structural stability and sparsity. Using the estimated influence structure, we highlight service quality interventions impacting consumers' buying patterns.

■ SB17

CC- Room 305

Advances in Service Operations

Sponsored: Manufacturing & Service Oper. Mgmt/Service Operations

Sponsored Session

Chair: Tarek Abdallah, Northwestern University

1 - Demand Visibility and Capacity Pooling Given Commitments

Pol Boada-Collado, Northwestern University, Evanston, IL, United States, boada.pol@u.northwestern.edu, Sunil Chopra, Karen Smilowitz

We study the value of limited demand visibility and capacity pooling, two hedging mechanisms against demand uncertainty, for signing capacity contracts with temporal commitment. Previous studies show that, without commitment, the two mechanisms are substitutes. We show that the commitment imposed across periods leads to new dynamics in which demand visibility and capacity pooling act as both substitutes and complements.

2 - Mechanism Design with Approximate Incentive Compatibility

Francisco Castro, Columbia University, Columbia School of Business, New York, NY, 10027, United States, Santiago Balseiro, Omar Besbes

We study the problem of selling an item to a buyer who might not accurately assess her utility from a transaction, and thus may make only near-optimal decisions. We consider the standard Myerson setting and, to capture that the buyer is not a perfect optimizer, we allow the incentive compatibility constraints to be satisfied up to . We establish a link between reporting strategies and a set of delayed differential equations that enable us to characterize the structure of the optimal selling mechanism. Our characterization features an unexpected phase transition. For =0, it is a posted price mechanism. However, for small , it requires randomization—a departure from the classic bang-bang solution.

3 - Demand Estimation under the Multinomial Logit Model from Sales Transaction Data

Tarek Abdallah, Northwestern University, Kellogg School of Management, Evanston, IL, 60614, United States, tarek.abdallah@kellogg.northwestern.edu, Gustavo J. Vulcano

We propose a method for computing maximum likelihood estimates for a multinomial logit model of demand from (incomplete) transactional data. The model is non-identifiable in general, but we characterize conditions under which this feature is overcome. The conditions rely on building a directed graph based on the input data and checking if it is strongly connected. We also discuss conditions under which the estimates are consistent. Our estimation proposal is based on a Maximize-Minorize (MM) algorithm that inherits the strongest convergence properties of this type of framework.

4 - Fitting Large-scale Mixture of Logit Models: A Convex Optimization Approach

Ashwin Venkataraman, UT Dallas, Dallas, TX, 02139, United States, Srikanth Jagabathula, Lakshminarayanan Subramanian

A key challenge in estimating mixture models is that the mixing distribution is often unknown and imposing apriori parametric assumptions can lead to model misspecification issues. We propose a new methodology for nonparametric estimation of the mixing distribution. We formulate the likelihood-based estimation problem as a constrained convex program and our key contribution is applying the conditional gradient (aka Frank-Wolfe) algorithm to solve this convex program, showing that it iteratively generates the support of the mixing distribution. We show that our estimator is robust to different ground-truth mixing distributions and outperforms the EM benchmark in two case studies on real data.

■ SB18

CC- Room 306

Energy and Sustainable Operations

Sponsored: Manufacturing & Service Oper. Mgmt/Supply Chain

Sponsored Session

Chair: Yangfang Zhou, Singapore Management University, Singapore, 178899, Singapore

Co-Chair: Melvyn Sim, National University of Singapore, Singapore, 119245, Singapore

1 - Electricity Pricing with Limited Consumer Response

Fariba F. Mamaghani, University of Texas at Dallas, Dallas, TX, United States, fxf150430@utdallas.edu, Saed Alizamir, Shouqiang Wang

We construct a demand model to describe how rationally inattentive consumers make consumption decisions in response to their ambient environment for a given price and how firms take advantage of it to optimize their profit. Subsequently, we investigate implication of monopolistic firm's pricing decision on social welfare and system reliability.

2 - Managing EV Charging Stations

Li Chen, National University of Singapore, Singapore, chen_l@u.nus.edu, Long He, Yangfang Zhou

We consider the charging of electrical vehicles in a charging station with uncertain arrival and departure times and charging quantity to minimize the total expected costs. We formulate the problem as a steady-state stochastic program (SP) incorporating these uncertainties with an electricity tariff including demand charge. To solve the large-scale SP, we develop exponential cone program approximations (ECP-U and ECP-C respectively for uncapacitated and capacitated charging station). We provide a theoretical performance guarantee for ECP-U and show better numerical performance of ECP-C compared with other approaches on real data set and offer managerial insights via sensitivity analysis.

3 - Collaborative Vehicle-to-grid Operations in Electricity Regulation Markets

Ho-Yin Mak, University of Oxford, Park End Street, Oxford, OX1 1HP, United Kingdom, ho-yin.mak@sbs.ox.ac.uk

We study the problem of electric vehicles (EVs) providing regulation services to the grid, coordinated by a vehicle-to-grid platform. We model the platform's problem as a bilevel program: At the upper level, the platform varies price incentives to procure capacity from EVs and determines capacity bids in the regulation market; At the lower level, individual drivers optimize travel and charging schedules in response to pricing incentives. To account for uncertainties and heterogeneity in regulation market prices and travel patterns, we make use of distributionally-robust optimization techniques to obtain a tractable convex optimization formulation for the problem.

4 - Net-metered Distributed Renewable Energy: A Peril for Utilities?

Nur Sunar, UNC, Chapel Hill, NC, 27517, United States, nur_sunar@kenan-flagler.unc.edu, Jayashankar M. Swaminathan

Electricity end-users have been increasingly generating their own electricity via rooftop solar panels. Our paper studies the implications of such "distributed renewable energy" for utility profits under net metering that has sparked heated debates in practice. Our analysis shows that in contrast to the common belief in practice, the presence of net-metered distributed renewable energy can result in strictly larger expected profit for utilities when wholesale market dynamics are factored in. Using data for distributed solar energy in California and the CAISO's wholesale electricity market, we demonstrate that our results are valid when the parameters are set to realistic values.

■ SB19

CC- Room 307

Joint Session MSOM/SC/Practice Curated: Food and Agriculture Supply Chain Analytics

Sponsored: Manufacturing & Service Oper. Mgmt/Supply Chain

Sponsored Session

Chair: Retsef Levi, MIT, Cambridge, MA, 02142, United States

1 - Supply Chain Coordination and Transparency for On-time Delivery

Elisabeth Paulson, MIT, 1164 Smithfield Street, Cambridge, MA, 16801, United States, epaulson@mit.edu

This work explores how supply chain visibility and coordination can be used to increase on-time delivery of perishable gods from suppliers to retailers. We consider a supply chain consisting of two independent retailers who source substitutable items from two suppliers. The suppliers strategically choose order fulfillment schedules, which may consist of early/late deliveries. We find that a coordinated setting—where the suppliers cooperate to fulfill orders or share complete information with the retailers—can improve on-time delivery significantly while decreasing suppliers' costs. A more realistic setting with partial visibility can achieve most of the gains of the coordinated setting.

2 - Artificial Shortage in Agricultural Supply Chains

Yanchong Zheng, Massachusetts Institute of Technology, Sloan School of Management, Cambridge, MA, 02139, United States, Retsef Levi, Somya Singhvi

Artificial shortages that lead to exorbitant increase in retail prices of essential commodities despite inventory availability is a matter of great concern for the governments, who employ a range of strategies to mitigate this phenomenon and its impact. This work develops analytical models to capture the dynamics of artificial shortages and impact of government interventions on consumer behavior and market prices. We validate our models using retail price data from India and highlight that to be effective, interventions need to be carefully designed while taking potential strategic responses of other players into account.

3 - Increasing Farmers' Income in Agricultural Markets: Evidence from a Field Implementation

Somya Singhvi, MIT, Cambridge, MA, 02139, United States, ssinghvi@mit.edu, Retsef Levi, Yanchong Zheng, Manoj Rajan

Lack of competition in agricultural markets has led to poor outcomes for farmers in many developing countries. In this work, we collaborate with the state government of Karnataka to implement an updated two-stage auction on their Unified Market Platform (UMP). The design was launched in February 2019, and more than 9000 lots worth $6 million USD have been traded through the new design so far. Using a Difference-in-Differences approach, we estimate significant positive gains from the new design. A combination of field surveys and an analytical behavioral model allow us to test and validate various behavioral factors that may help explain the results.

4 - Supply Chain Analytics Guiding Food Inspections

Nicholas J. Renegar, Massachusetts Institute of Technology, Cambridge, MA, 02139, United States, renegar@mit.edu

In this talk, we describe how analytics can provide major regulatory insights regarding supply chain sources of adulteration, risk-based regulatory resource allocation and regulatory enforcement. The work is based on unique integrated database of publically available CFDA food inspections results, as well as additional publically available databases. It leverages text analytics, machine learning, supply chain analysis and technical analysis of adulterants.

■ SB20

CC- Room 308

Publishing in INFORMS Transactions on Education

Sponsored: Education

Sponsored Session

Chair: Jeroen Belien, KU Leuven, Brussel, 1000, Belgium

1 - Editor-in-chief ITE

Jeroen Belien, KU Leuven, Warmoesberg 26, Brussel, 1000, Belgium, jeroen.belien@kuleuven.be

We discuss which types of papers (regular papers, case studies, classroom games, puzzles) are currently published in ITE. Furthermore, we interact with the audience on how ITE should proceed in order to become the flagship journal in OR/MS/analytics education.

2 - Recent Author ITE

Eric Logan Huggins, Fort Lewis College, 1000 Rim Drive, Durango, CO, 81301, United States

3 - Area Editor Case Studies

David P. Kopcso, Babson College, 231 Forest Street, Dept. of Math and Science, Babson Park, MA, 02457-0310, United States

4 - Area Editor Classroom Games

Stefan Creemers, Professor, IESEG, Lille, France

5 - Panelist

Madhu Rao, Stetson University, FL, United States

■ SB21

CC- Room 309

Commodity and Energy Risk

Sponsored: Manufacturing & Service Oper. Mgmt/iFORM

Sponsored Session

Chair: Nicola Secomandi, Carnegie Mellon University, Pittsburgh, PA, 15213, United States

1 - Strategic Forward Trading and Technology

Heikki Peura, Imperial College Business School, South Kensington Campus, London, SW7 2AZ, United Kingdom, Derek W. Bunn

Additional wind power is expected to reduce power prices by displacing incumbent gas generators by virtue of its lower production costs. We revisit this so-called merit-order effect of renewables, accounting for operational factors such as wind intermittency. Analysing a spot-forward market with imperfect competition, we find that intermittency may cause producers to behave less aggressively in forward trading for fear of unfavorable spot-market positions. Equilibrium prices may then paradoxically increase with more wind power, even though both renewables and forward trading are separately viewed as pro-competitive.

2 - An Alternating Direction Method of Multipliers Approach to Pathwise Optimization in Merchant Energy Production

Bo Yang, Carnegie Mellon University, Pittsburgh, PA, 15213, United States, Selvaprabu Nadarajah, Nicola Secomandi

Pathwise optimization (PO) is an approximate dynamic programming approach that has been successfully applied to intractable Markov decision processes that arise in merchant energy production and related optimal stopping contexts. The difficulty of solving its underlying large-scale linear program currently limits its practical applicability. We address this issue by developing an alternating direction method of multipliers algorithm with improved computational complexity relative to a state of the art method. Our technique increases by a factor of 1.5 the size of instances that PO can handle.

3 - Estimating Dynamic Conditional Spread Densities to Optimize Daily Storage Trading of Electricity

Derek Bunn, London Business School, London, United Kingdom, Ekaterina Abramova

This paper formulates dynamic density functions, based upon skewed-t and similar representations, to model and forecast electricity price spreads between different hours of the day. This supports an optimal day ahead storage and discharge schedule, facilitating a trading strategy for a merchant arbitrage facility. The four latent moments of the density functions are dynamic and conditional upon exogenous drivers, permitting the mean, variance, skewness and kurtosis of the densities to respond hourly to weather and demand forecasts. Analytical properties allow the calculation of risk associated with the spread arbitrages.

4 - Optimization of Option Exercise Policies in Incomplete Markets with Quadratic Hedging

Nicola Secomandi, Carnegie Mellon University, Tepper School of Business, Pittsburgh, PA, 15213, United States

Quadratic hedging is a practically appealing approach for approximately replicating the random payoffs of European options in incomplete markets. This work extends this methodology to the case of Bermudan options, for which an exercise policy needs to be optimized. The resulting optimal option exercise policies are in general time inconsistent. Time consistent option exercise policies can be optimized recursively. The proposed approach is relevant to both financial and real options.

■ SB22

CC- Room 310

Emerging Issues in Circular Economy

Sponsored: Manufacturing & Service Oper. Mgmt/Sustainable Operations

Sponsored Session

Chair: Cerag Pince, Quinlan School of Business, Loyola University Chicago, Chicago, IL, 60611, United States

1 - Emerging Topics in Circular Economy and Sustainable Operations

Cerag Pince, Quinlan School of Business, Loyola University Chicago, Chicago, IL, 60611, United States

In this panel, speakers from academia will share their views on emerging challenges in circular economy and discuss potential future research avenues. With perspectives drawn on recent research findings, the topics covered will include the impact of leasing on circular business models, servicing and sharing economy, environmental strategy and policy issues, sustainability challenges in agricultural and food supply chains, and future of closed-loop supply chains with emerging technologies.

Panelist

Tamer Boyaci, ESMT Berlin, Berlin, 10119, Germany, tamer.boyaci@esmt.org
Ravi Subramanian, Georgia Institute of Technology, Scheller College of Business, Atlanta, GA, 30308, United States, ravi.subramanian@scheller.gatech.edu
Vishal Agrawal, Georgetown University, Washington, DC, 20057, United States

■ SB23

CC- Room 3A

Structuring Decisions for Analysis and Evaluation

Sponsored: Decision Analysis

Sponsored Session

Chair: Ralph L. Keeney, Duke University, San Francisco, CA, 94111, United States

1 - Structuring Decisions using Mental Models

James S. Dyer, The University of Texas at Austin, Austin, TX, United States, Saurabh Bansal

Management decisions are often based on the consideration of a number of factors or attributes that seem relevant to the decision. A manager may subjectively consider these factors and then make a decision based on a cognitive understanding of these factors that we call a mental model. We discuss how a more formal approach to decision making based on formally recognizing these mental models and making them explicit can improve decision making.

2 - Partitioning the Value of Countermeasure Deployment: Estimating the Expected Value of Deterrence

Richard S. John, Professor, University of Southern California, Dept of Psychology MC 1061, Los Angeles, CA, 90089-1061, United States, richardj@usc.edu, Nicholas Scurich

I describe a methodology for adapting Defender-Attacker Decision Trees (DADTs) to partition the value of adversary countermeasures into three components: Threat reduction (deterrence), vulnerability reduction, and consequence mitigation. The Expected Value of Imperfect Control (EVIC) can be partitioned into three non-additive components: Expected Value of Imperfect Deterrence (EVID), Expected Value of Vulnerability Reduction (EVVR), and Expected Value of Consequence Mitigation (EVCM). I provide an example DT and calculation for deploying dogs at airport passenger screening checkpoints that illustrates overlap among the three components and the problem of double counting.

3 - The Relative Benefits of Pursuing Decision Opportunities and Decision Problems

Johannes Ulrich Siebert, Profersson, Management Center Innsbruck, Universitaetsstr 15, Innsbruck, 6020, Austria, Christian Hannes, Rüdiger von Nitzsch

Decision situations are usually called and faced as decision problems. Most of the decision-theoretic methods contribute to solving these “problems”. Keeney argues that decision makers who are “solving problems” only restore the situation to how it was before and suggests proactively creating decision opportunities to improve the quality of life. In our study, we analyzed individual decision situations and gathered empirical evidence about the relative consequences of addressing decision problem and decision opportunities.

4 - Constructing a Decision Frame for Analysis and Evaluation

Ralph L. Keeney, Duke University, Durham, NC, United States, KeeneyR@aol.com

Constructing a decision frame provides an unambiguous and complete description of the decision to be made. It begins with a statement of the decision, which provides a guideline for identifying the relevant objectives to be achieved and a full set of alternatives for this decision. Procedures are described to efficiently and thoroughly create the objectives and alternatives that are the foundation for analysis and evaluation.

■ SB24

CC- Room 3B

Junior Researcher Best Paper Award

Sponsored: Multiple Criteria Decision Making

Sponsored Session

Chair: Serpil Sayin, Koc University, Istanbul, 34450, Turkey

1 - Quadratic Scalarization for Decomposed Multiobjective Optimization

Brian Dandurand, Argonne National Laboratory, Lemont, IL, 60439, United States, Margaret M. Wiecek

For nonconvex multiobjective optimization problems (MOPs), linear scalarization methods can fail to support the entire Pareto efficient set. A quadratic scalarization method (QSM) is developed as a solution approach which preserves decomposable structures of the MOP and avoids introducing a high degree of nonlinearity and additional nonsmoothness. Under mild assumptions, necessary and sufficient conditions for QSM-generated solutions to be local weakly and properly efficient for an MOP are developed. QSM is shown to correspond with the relaxed, reformulated weighted-Chebyshev method as a special case. An example is provided for demonstrating the application of QSM to a nonconvex MOP.

2 - Heuristics for Prioritizing Pair-wise Elicitation Questions with Additive Multi-attribute Value Models

Milosz Kadzinski, Poznan University of Technology, Poznan, 60-965, Poland

Indirect techniques that employ pair-wise questions are commonly used for lowering the Decision Maker’s effort related to the elicitation of additive value models. We develop heuristics for prioritizing such questions based on the outcomes of robustness analysis with the aim of minimizing the number of answers required for ranking the alternatives. Extensive numerical experiments allow us to identify a subset of heuristics that score well on different metrics in a variety of problem settings. This conclusion was validated in a real-world experiment where 101 subjects answered pair-wise questions to rank 10 mobile phone packages evaluated in terms of 4 criteria.

3 - Trade-off Preservation in Inverse Multi-objective Convex Optimization

Taewoo Lee, University of Houston, Houston, TX, 77204-4008, United States

Given an input solution that may not be Pareto optimal, we present a new inverse optimization methodology for multi-objective convex optimization that determines a weight vector producing a weakly Pareto optimal solution that preserves the decision maker’s trade-off intention encoded in the input solution. We introduce a notion of trade-off preservation, which we use as a measure of similarity for approximating the input solution and show its connection with minimizing an optimality gap. We also show that our model encompasses many of the existing inverse optimization models. We demonstrate the proposed method in cancer therapy applications.

■ SB25

CC- Room 401

Joint Session Interface of M&O/Practice Curated: Game Theory for Marketing-Operations Interface II

Emerging Topic: Interface of Marketing & Operations

Emerging Topic Session

Chair: Tinglong Dai, Johns Hopkins University, Baltimore, MD, 21202, United States

1 - Wage Transparency and Social Comparison in Salesforce Compensation

Xiaoyang Long, University of Wisconsin-Madison, Wisconsin School of Business, Madison, WI, 53706, United States, xiaoyang.long@wisc.edu, Javad Nasiry

When wages are transparent, sales agents may compare their pay with that of their peers and experience positive or negative feelings if those peers are paid (respectively) less or more. We investigate the implications of such social comparisons on sales agents' effort decisions and their incentives to help or collaborate with each other. We then characterize the firm's optimal salesforce compensation scheme and the conditions under which wage transparency benefits the firm.

2 - Dynamic Salesforce Incentives with Inventory Considerations

Olivier J. Rubel, UC Davis Graduate School of Management, Davis, CA, 95616, United States

We propose a dynamic principal-agent model where the agent sells a product, while the principal manages its rate of production, its price, as well as the agent's compensation plan. We characterize the optimal strategies that dynamically stabilize the firm's operations.

3 - Assign the Right Person or Train Them to Do the Right Task: A Model of Key Account Manager

Ying Yang, University of Iowa, Iowa City, IA, United States, ying-yang@uiowa.edu

By an information-theoretic model of the Key Account Manager (KAM), we found out that the success of key account selling depends on two important responsibilities of the key account manager: assigning the right specialist and training them to do the right task. Both are necessary conditions for a happy customer and thus a sale. Interestingly, the interaction between the team members' incentives causes the KAM to double reverse strategic choices between exceptional assigning and training. When there is a conflict of interest between the team and the firm, a managerial recommendation to the firm is to mitigate the conflict by compensating the specialists rather than the KAM.

4 - Service Design under Acclimation and Non-homogeneous Memory Decay

Tinglong Dai, Johns Hopkins University, Baltimore, MD, 21202, United States, dai@jhu.edu, Yifu Li, Xiangtong Qi

We study the optimal sequencing and selection of activities a service package comprises to creating memorable, delightful customer experiences. Prior theoretic literature, however, suggests that the peak activity should be scheduled either at the beginning or the end, contradicting empirical evidence of "interior peaks." Our paper bridges the gap in the literature and lends theoretic support to empirical findings. We also analyze the problem of activity selection and show it can be optimal to choose a portfolio of activities with either the highest or lowest utility values, but not those with medium utility values.

■ SB26

CC- Room 4C-1

Best Service Science Paper I

Sponsored: Service Science

Sponsored Session

Chair: Ming-Hui Huang, National Taiwan University, Taipei, 10617, Taiwan

1 - Multi-objective Optimization for Political Districting: A Scalable Multilevel Approach

Sheldon H. Jacobson, University of Illinois, Dept. of Computer Science, Urbana, IL, 61801-2302, United States, shj@illinois.edu, Rahul Swamy, Douglas M. King

The notion of fairness in political districting has been an important topic of subjective debate, with district maps having consequences to multiple stakeholders. This paper introduces optimization models for districting with political fairness criteria. The criteria considered are based on fundamental fairness principles such as vote-seat proportionality (efficiency gap), partisan (a)symmetry, and competitiveness. The results demonstrate that district plans constituting the Pareto-front are equitable, symmetric, competitive, and compact, and that a multi-objective approach is integral to paving the way towards a holistic districting process that addresses all the stakeholders.

2 - Service Design of Non-profits that Serve Distressed Individuals

Priyank Arora, University of Massachusetts-Amherst, Amherst, MA, United States, parora@isenberg.umass.edu, Morvarid Rahmani, Karthik Ramachandran

Non-profit organizations that serve distressed individuals are driven to not only offer a variety of services, but also engage in advisory activities to minimize mismatches between services clients receive and their true needs. We study the portfolio and service design problem for resource-constrained NPOs that aim to maximize their impact.

3 - When Transparency Fails: Bias and Financial Incentives in Ridesharing Platforms

Christopher Dalton Parker, Pennsylvania State University, University Park, PA, United States, Jorge Mejia

Previous research documents racial/gender biases by drivers for ridesharing platforms. Firms removed riders' names and pictures from the ride request presented to drivers in an attempt to reduce this bias. Our primary research question is whether this change has indeed removed the biases. We investigate this through a large field experiment on a major ridesharing platform in Washington, DC. Racial and LGBT biases are persistent, while we find no evidence of gender biases. Peak times moderate (through increased pay) rather than exacerbate (by allowing drivers to be more selective) these biases for non-caucasian riders. We do not find a similar moderating effect for supporters of the LGBT community.

4 - Detecting Customer Trends for Optimal Promotion Targeting

Lennart Baardman, University of Michigan, Ann Arbor, MI, United States, baardman@umich.edu, Setareh Borjian Boroujeni, Tamar Cohen-Hillel, Kiran V. Panchamgam, Georgia Perakis

Detecting trends in fashion can help retailers determine effective personalized promotion plans more easily. Social media data is valuable in understanding these trends, but it is often unavailable. We introduce a personalized demand model that captures customer trends from transaction data instead. We base our efficient estimation method on instrumental variables, which allows us to draw causal inference on the effects that targeted promotions have. The promotion targeting problem is NP-hard to solve, so we develop an efficient and provably-good greedy approach. Finally, with real fashion retail data, we estimate our customer trend model and test the promotion targeting algorithm.

5 - Heuristic Thinking in Patient Care

Diwas S. KC, Emory University, Goizueta Business School, Atlanta, GA, 30322, United States

We study heuristic thinking in the patient discharge decision at acute care hospitals. Determining a patient's suitability for discharge is cognitively taxing. We postulate that bounded rationality leads the care provider to substitute clinical readiness for discharge - a more cognitively complex attribute, with a more easily accessible heuristic.

6 - The Spillover Effects of Employee-customer Interactions: Field Evidence from an Online Education Platform

Dennis Zhang, Washington University in St Louis, St Louis, MO, 63130, United States, denniszhang@wustl.edu, Hengchen Dai

Maintaining productivity and service quality across employee-customer interactions has important implications for business. How does a single employee-customer interaction, particularly an interaction in which the customer underappreciates the employee's effort and time, influence the employee's effort provision the next time she interacts with a different customer? We address this question using a large-scale dataset recording interactions between teachers and their students on an online education platform.

■ SB27

CC- Room 4C-2

Service Customer

Contributed Session

Chair: Jiangning He, Shanghai University of Finance and Economics

1 - Service Commitment and Customers Response: An Empirical Study on Effects of Delivery Lead Time Commitment on Online Ratings

Ho Cheung Brian Lee, University of Massachusetts-Lowell, Lowell, MA, United States, brian_lee@uml.edu, Nichalin S. Summerfield, Amit Deokar, Ali Ahmed

Service commitment is a commonly used operational strategy to attract customers. While the literature has reported the advantages of service commitment, its impact on the online word of mouth of a firm remains unexplored. We examine how the online rating behavior may be influenced by the delivery lead time and promised delivery date for online orders. This study shows that the service commitment reduces the customers' rating participation propensity and online customer ratings as they may be affected by the changes in customers's pre-purchase expectation.

2 - A Consumer Perspective on Blockchain Technology in Shared Mobility Services

Christopher Grossmann, EBS Universitaet fuer Wirtschaft und Recht, Wiesbaden, Germany, christopher.grossmann@ebs.edu, Katrin Merfeld

While traditionally OEMs relied on permanent vehicle acquisition, peer-to-peer sharing services now empower consumers to offer mobility as a service. However, many consumers are still reluctant to use shared services, and respective insights remain scarce. One approach to overcome those hurdles is the implementation of blockchain technology. Still, it is questionable whether in shared mobility services the technology creates consumer-perceived value. This paper provides an overview of the literature, business cases, and applies the means-end chain approach to qualitatively elicit consumers' motivational structures towards blockchain technology in peer-to-peer sharing.

3 - Mining Consumer Involvement to Improve Mobile App Recommendation

Jiangning He, Assistant Professor, Shanghai University of Finance and Economics, Shanghai, China, he.jiangning@sufe.edu.cn, Fang Xiao, Hongyan Liu

Given the ubiquitous role of mobile apps in people's lives as well as the sheer size of the mobile app market, developing effective mobile app recommendation methods is critical for both mobile app users and platforms. Premised in involvement theory, we propose a novel mobile app recommendation method that integrates both download and browsing behaviors to learn users' overall interests in and involvement with apps, in contrast to existing methods that rely on download behaviors but neglect browsing behaviors. Our experimental results based on a real large mobile app dataset demonstrate the superior performance of our method over several state-of-the-art mobile app recommendation methods.

4 - Reevaluating Order Fulfillment Plans in Real Time in an Online Retail Environment

Matthew Petering, University of Wisconsin-Milwaukee, Milwaukee, WI, United States, mattpete@uwm.edu, Amir Kalantari

We use discrete event simulation and optimization to compare options for automatically assigning and reassigning the orders placed with an online retailer to the retailer's fulfillment centers. We show that online retailers can significantly reduce total shipping costs by intelligently reevaluating their order fulfillment plans.

■ SB28

CC- Room 4C-3

Operational Issues in Service Economy

Sponsored: Service Science

Sponsored Session

Chair: Rakesh Reddy Mallipeddi, Texas A&M University, College Station, TX, 77843-4217, United States

1 - Safety Stock Allocation in Online Retailing Network under Demand Uncertainty and Lost Sales

Mayukh Majumdar, Texas A&M University, College Station, TX, United States, Chelliah Sriskandarajah, Anupam Agrawal

It is a challenge for online retailers to balance the trade-off between expensive transshipment and safety stocks to fulfill customer demand on time. We examine the allocation of safety stocks in a large online retailing network consisting of several fulfillment centers with an objective to minimize the total cost composed of transportation, inventory holding, and lost sales. We formulate a stochastic optimization model under a periodic-review inventory system with demand uncertainty and analyze a large and complex network. This work generates valuable insights and provides an easy-to-implement procedure to allocate safety stocks.

2 - The Impact of Collaboration in Cross-docking Supply Chains

Seulchan Lee, Mays Business School, College Station, TX, United States, slee@mays.tamu.edu, Alexandar Angelus, Chelliah Sriskandarajah

The recent increase in the shipment frequency with small load sizes in distribution logistics has motivated many logistics service providers to collaborate with their partners. An increasing number of supply chain networks with cross-docking function explores opportunities to enhance collaboration at successive stages (i.e., vertical collaborations), or at the same stage within the distribution channels (i.e., horizontal collaborations). We provide an optimization framework and analyze the properties of optimization models in order to derive implications of vertical and horizontal collaborations in scheduling inbound and outbound shipments in the three-stage supply chain.

3 - Dynamics in Ethical Decision Making

Xingzhi Jia, Mays Business School, Wehner Building, College Station, TX, 77843, United States, xjia@mays.tamu.edu, Xenophon Koufteros

We investigate ethical decision-making and examine the dynamics between consecutive decisions that invoke ethical considerations in supply management. Instead of focusing on individual instances of ethical decision-making, we investigate an individual's ethical decision-making behaviors in the long term (10 decisions over 10 weeks) via a stochastic process methodology.

4 - Capacity Planning for Ambulatory Surgery Centers: A Bottom-up Strategy Based on Optimization Combined with Data Analytics

Seokjun Youn, The University of Arizona, Tucson, AZ, 77840-4217, United States, syoun@email.arizona.edu, Harry Neil Geismar, Chelliah Sriskandarajah, Vikram Tiwari

Timely capacity adjustment is essential for the surgery center planners, but the related research is limited. In contrast to the traditional top-down approach to capacity planning, our approach proposes a bottom-up strategy based on optimization methods combined with analytics that are informed by operational-level archival patient flow data. We develop mathematical formulations and algorithms based on scheduling theory to derive the most cost-efficient capacity solution for the multi-stage structure of surgery centers. In the computational study, we further show how uncertain business parameters can affect capacity planning decisions.

■ SB29

CC- Room 4C-4

Advances in Auction Design

Sponsored: Auction and Market Design

Sponsored Session

Chair: Benjamin Lubin, Boston University, Boston, MA, 02215, United States

Co-Chair: Sven Seuken, University of Zurich, Zurich, 8050, Switzerland

1 - Cloud Pricing: The Spot Market Strikes Back

Ludwig Dierks, University of Zurich, Binzmÿhlestrasse 14, Zurich, Switzerland, Sven Seuken

Cloud computing providers must constantly hold many idle compute instances available. A natural idea to increase profits is to sell these idle instances on a secondary market, for example, via a preemptible spot market. However, this ignores possible ``market cannibalization” effects that may occur in equilibrium as well as the additional costs the provider experiences due to preemptions. To study the viability of secondary markets, we combine queuing theory and game theory. Our main result is an easy-to-check condition under which a provider can achieve a profit increase and create a Pareto improvement for the users by offering a spot market (using idle resources) alongside a fixed-price market.

2 - Testing Dynamic Incentive Compatibility in Display Ad Auctions

Sébastien Lahaie, Google Research, New York, NY, United States, Yuan Deng

This paper develops statistical tests that a bidder in a display ad auction can use to confirm whether the underlying auction mechanism is dynamically incentive compatible (IC), so that truthful bidding in each individual auction and across time is an optimal strategy. We characterize dynamic mechanisms that are dynamic-IC for all possible time-discounting factors according to two intuitive conditions, which motivate two separate tests: the mechanism should be IC at each stage, and expected present utility should be independent of past bids. We evaluate the tests on display ad data from a major ad exchange.

3 - Deep Learning-powered Iterative Combinatorial Auctions

Jakob Weissteiner, University of Zurich, Zurich, Switzerland, Stefania Ionescu, Nils Olberg, Sven Seuken

We study the design of machine learning-powered iterative combinatorial auctions (ICAs). We build on Brero et al., who have successfully integrated support vector regression (SVRs) into the preference elicitation algorithm of an ICA. However, with expressive kernels, the winner determination problem (WDP) cannot be solved for large domains. We address this shortcoming by using deep neural networks (DNNs) instead of SVRs. We show that the resulting maximization step of DNNs with ReLu activations can be reformulated into a MILP and solved efficiently. First simulation results indicate that even small DNNs outperform SVRs with expressive kernels.

4 - Parametric Mechanism Design under Uncertainty

Enrique Areyan, Brown Univeristy, Providence, RI, United States, enrique_areyanviqueira@brown.edu

We introduce a methodology for the design of multiagent systems inhabited by strategic agents. We assume agents play approximate equilibria, which we estimate using the probably approximately correct learning framework. Under this assumption, we learn approximately optimal mechanism parameters. We do this theoretically, assuming a finite design space, and heuristically, using Bayesian optimization (BO). Our BO algorithm incorporates noise associated with modern concentration inequalities, such as Hoeffding's, into the underlying Gaussian process. We show experimentally that our search techniques outperform standard baselines in a stylized but rich model of advertisement exchanges.

5 - Online Learning for Measuring Incentive Compatibility in Ad Auctions

Zhe Feng, Harvard University, Cambridge, MA, 02138, United States, zhe_feng@g.harvard.edu, Okke Schrijvers, Eric Sodomka

In this paper we investigate the problem of measuring end-to-end Incentive Compatibility (IC) regret given black-box access to an auction mechanism. Our goal is to 1) compute an estimate for IC regret in an auction, 2) provide a measure of certainty around the estimate of IC regret, and 3) minimize the time it takes to arrive at an accurate estimate. We consider two main problems: In the advertiser problem the goal is to measure IC regret for some known valuation v, while in demand-side platform (DSP) problem we wish to determine the worst-case IC regret over all possible valuations. The problems are naturally phrased in an online learning model and we design Regret−UCB algorithms for both problems.

■ SB29a

CC- Room 400

Health Care, Modeling and Optimization II

Contributed Session

Chair: Iqra Ejaz, Texas A&M University, College Station, TX, 77843, United States

1 - Optimizing the Continuum of HIV Care in Vancouver, Canada

Alexander R. Rutherford, Simon Fraser University, Burnaby, BC, Canada, arruther@sfu.ca, Benny Wai, Sarah Kok, Reka Gustafson, Rolando Barrios, Krisztina Vasarhelyi

A combined systems dynamics and compartmental epidemiological model was developed for the continuum of HIV care in Vancouver, Canada, as part of a long-term collaboration to improve quality of care and reduce new infections under health care cost constraints. The model captures testing, treatment, engagement in care, and retention in care for men who have sex with men, injection drug users, sex workers, and the general population. Model optimizations were performed to identify strategies for reducing HIV incidence, morbidity, and mortality. Key recommendations include expanding routine HIV testing in acute care settings and focusing intensive case management to injection drug users.

2 - Preferred Post-acute Provider Network: An Approach to Improve Care Coordination in Healthcare Continuum

Ineen Sultana, Texas A&M University, College Station, TX, United States, ineensultana@tamu.edu, Lewis Ntaimo, Mark Lawley

Post-acute care (PAC) provides treatment for critical patients following hospital discharge to further improve patient outcomes. To ensure availability of PAC, an effective care coordination from acute care facilities (ACF) to PAC facilities is a long due necessity. Building a Preferred Post-Acute Network (PPN), which involves a contract agreement between ACF and PAC, can strengthen this care coordination. The aim of this study is to develop strategic agreement decisions and resource adjustment planning to form a PPN. In this study, a two-stage stochastic mixed integer model is proposed to optimize the decision features of PPN formation considering uncertainty in resources and patient demand.

3 - Sepsis Patient Hospitalizations from Home Health Care – Risk Models, Early Identification and Care

Jakka Sairamesh, CEO and President, CapsicoHealth, Inc, San Francisco, CA, United States, ramesh@capsicohealth.com, William Stein-III, Laurent Hasson, Arun Villivalam

Sepsis care costs CMS (Center for Medicare and Medicaid) 14 Billion per year for Medicare patients. Over 1 in 10 Sepsis patients are hospitalized yearly, and over 24.5% hospitalized from home health care within the first 30-days of home care. Our studies have shown 20% hospitalization rates within the first 7-days of home health care when considering all Sepsis hospitalizations from home care. Our data includes several million Medicare claims from 2016-Q1 to 2018-Q1. Our risk prediction models show a ROC of 0.81. Factors include comorbidities, age, previous hospitalizations and utilization. Early identification will help reduce 7-day hospitalizations during the early phase of home health care.

4 - A Decomposition Method for the Dynamic Home Health Care Routing and Scheduling Problem

Florian Grenouilleau, PhD Candidate, Ecole Polytechnique de Montreal, Montreal, QC, Canada, florian.grenouilleau@cirrelt.net, Nadia Lahrichi, Louis-Martin Rousseau

Due to the aging of the population, the demand in home health care services have greatly increased during the past decade. In order to manage this demand, an improvement of the resources utilization is necessary. In this work, we are interested in the dynamic home health care routing and scheduling problem. The objective here is to develop a decomposition method based on scenarios in order to dynamically accept and schedule new patients in the system while conserving a high quality of service for existing patients.

5 - A Multilevel Cost-saving Modeling of Accountable Care Organizations

Jiajia Qu, University at Buffalo, SUNY, Buffalo, NY, United States, Jiajiaqu@buffalo.edu, Meiling Jiang, Raj Sharman, Sanjukta Smith, Pamella Howell, Chet Fox

This paper proposed a decision-making modeling of Accountable Care Organizations, a new system of care and payment to tie the high-quality care to the reimbursement for providers. The primary goal is to help ACOs to structure incentive and intervention scheme to achieve their long-term sustainability from shared savings. With a multi-level nonlinear programming model capturing the interplay among multiple tiers, we develop several in-depth insights. First, we show the optimal intervention effort for physicians to intervene to mold patient behavior, to achieve highest the physician's surplus. Second, we discuss the optimal incentivize schemes to help ACO achieve cost-efficient.

6 - Effects of Nested Interruptions Experienced by Intensive Care Nurses on System Stability

Iqra Ejaz, Texas A&M University, College Station, TX, United States, Natarajan Gautam, Farzan Sasangohar, Mark Lawley

We develop an analytical model for nested interruptions experienced by intensive care nurses. Stability conditions and performance measures are derived for the system.

■ SB30

CC- Room 6A

Tutorial: The Fulfillment-Optimization Problem

Emerging Topic: Tutorials

Emerging Topic Session

1 - The Fulfillment-Optimization Problem

Vivek Farias, MIT, Cambridge, MA, 02142, United States, Jason Acimovic

This tutorial studies the fulfillment-optimization problem, a key optimization problem facing retailers who fulfill online customer orders using inventory that might be distributed across multiple supply nodes, which for omni-channel retailers may include the entire store network in addition to distribution centers. This tutorial formulates and studies the fulfillment optimization problem as an online optimization problem. The first approach we study to solving this problem is similar in spirit to LP-based bid price approaches to network revenue management. The second approach relies on an algorithm based on the primal-dual schema. The approaches are complementary; the first is suitable in a regime where the demand for products is relatively predictable, whereas the latter is applicable to settings where such predictability is not available. In both cases we describe the practical impact of these solutions at real-world retailers. Finally, we discuss outstanding unsolved problems in the area that we believe can have significant impact on practice.

■ SB31

CC- Room 6B

Decision Analysis and Theory in the Handbook of Military and Defense Operations Research

Sponsored: Military and Security

Sponsored Session

Chair: Natalie M. Scala, Towson University, Towson, MD, 21252, United States

Co-Chair: James P. Howard, Johns Hopkins Applied Physics Laboratory, Columbia, MD, 21045, United States

1 - Analytical Modeling of Stochastic Systems

Roger Chapman Burk, Associate Professor, United States Military Academy, Department of Systems Engineering, Bldg., West Point, NY, 10996-1779, United States, roger.burk@westpoint.edu

This presentation to promotes the modeling with analytical models rather than discrete event simulation (DES). DES has many advantages, but it also requires multiple runs and statistical treatment of their result and its model tend to grow in detail and complexity. Analytical models give quick answers, but they require a mathematical structure, and they are more abstract and harder to explain. Despite this balance, simulation is more widely used than analytical models in the practice of military operations research. A brief review of DES and analytical modeling is given, including the particular advantages and disadvantages of each. This is followed by a direct comparison and examples.

2 - Multiattribute Decision Modeling in Defense Applications

Roger Chapman Burk, Associate Professor, United States Military Academy, Department of Systems Engineering, Bldg., West Point, NY, 10996-1779, United States, roger.burk@westpoint.edu

The role of decision analysis (DA) within military operations research (OR) is discussed. A technically sound and easy-to-apply approach for multiattribute problems is presented, based on an additive value model. This includes developing a value hierarchy, identification of measures of value and of single-attribute value functions, and elicitation of attribute swing weights. Cost issues are addressed, as are issues of multiple stakeholders. The ramifications of decisions under uncertainty are then considered. The emphasis is on practical methods that are technically sound but understandable by clients without special training in OR or DA, and on clear methods of presentation of results.

3 - Modern Methods for Characterization of Social Networks through Network Models

Christine Schubert Kabban, Air Force Institute of Technology, Wright Patterson AFB, OH, United States, Fairul Mohd-Zaid, Richard F. Deckro

Social Network Analysis is widely used by intelligence and operational communities to analyze relationships and monitor a network of interest. However, the social network must first be characterized to be effectively modeled. This work exhibits the use of statistical approaches to characterize social networks into specific network structures with quantifiable properties. We demonstrate such an approach for common network models and motivate future directions in this research area. Ideally, by capturing all the facets of a social network, a better understanding and representation of the network can be created for analysis and monitoring.

■ SB32

CC- Room 6C

George B. Dantzig Dissertation Prize

Emerging Topic: George B. Dantzig Dissertation Prize

Emerging Topic Session

Chair: Nicos Savva, London Business School, Regent's Park, London, NW1 4SA, United Kingdom

1 - Rethinking Customer Segmentation and Demand Learning in the Presence of Sparse, Diverse, and Large-scale Data

Ashwin Venkataraman, New York University, New York City, NY, United States

2 - The Edge of Large-Scale Optimization in Transportation and Machine Learning

Sebastien Martin, PhD, Massachusetts Institute of Technology, Cambridge, MA, 02139, United States

This thesis focuses on impactful applications of large-scale optimization in transportation and machine learning. These applications include online matching for ride-sharing, travel-time estimation, school transportation, and machine learning interpretability. Our contributions include methodology work and extensive numerical experiments. We collaborated with Boston Public Schools to implement our optimization and policy work. This resulted in millions of dollars of savings for the district every year, as well as important public policy consequences in the United States.

3 - Online Resource Allocation: Theory and Applications

Guodong Lyu, National University of Singapore, Singapore, 117592, Singapore

Please check the mobile app or online for this abstract

4 - Essays on Socially Responsible Operations

Can Zhang, Duke University, Durham, NC, 27708, United States

Please check the mobile app or online for this abstract

■ SB33

CC- Room 602

JuMP for Stochastic Optimization

Sponsored: Optimization/Computational Optimization and Software

Sponsored Session

Chair: Joaquim Garcia, PSR & PUC-Rio, Brazil

1 - Recent Developments in SDDP.jl

Oscar Dowson, Northwestern University, Evanston, IL, United States

In this talk we discuss recent improvements to SDDP.jl, an open-source multistage stochastic programming solver implemented in the Julia language. These include an update to Julia 1.0 and JuMP 0.19, as well as the ability to solve infinite-horizon multistage stochastic programs.

2 - Solving Multistage Stochastic Optimization Problems using JuMP

Thuener A. Silva, PUC-Rio LAMPS, Rio de Janeiro, 22451-900, Brazil, thuener@esp.puc-rio.br

JuMP and Julia ecosystem allows for great flexibility in research applications on optimization. Problems previously solved in a simplified way can now be easily constructed and solved using JuMP and the derived frameworks. This is the case for Multistage stochastic problems, which are very complicated to solve due to the increase in dimensionality. This allows us to focus our research more on modeling problems than solving those problems. Thus, several applications, for example, in energy, finance and corporate finance can now be modeled more accurately, taking into account realistic assumptions.

3 - Large Scale Stochastic Optimization in Power Systems with Julia and JuMP

Joaquim Masset Lacombe Dias Garcia, PSR Inc, Botafogo, Rio de Janeiro, 22250-040, Brazil, joaquimgarcia@psr-inc.com Joaquim Masset Lacombe Dias Garcia, PUC-Rio, Rio de Janeiro, Brazil, joaquimgarcia@psr-inc.com

Stochastic programming is a key tool for modern power systems simulation, operation and expansion. The large scale of these systems make problems of interest extremely large, tailored solutions are necessary to solve such problems. We will show how the Julia language and the Mathematical Modeling package JuMP were used to apply optimization algorithms to such problems. We highlight the nice performance, simplicity, interoperability and parallel programming features of Julia. JuMP will be shown to be a great asset because of its simplicity, efficiency and flexibility. Case study will detail the application of such tool in real power systems.

4 - A Scenario Based Single Vehicle Routing Problem with Stochastic Demands: Flow Models

Marcus V. Poggi, PUC-Rio, Rua M. S. Vicente 225, Rio de Janiero, 22591-900, Brazil, Georges Spyrides, Thibaut Vidal

We consider the problem of routing a single vehicle with capacity Q to collect demands from a set C of customers. Demands ds from a set S of scenarios are uncovered at arrival. The objective is to minimize expected routing distance. Two recourse policies are considered when vehicle capacity is exceeded: go to the depot and back to the current customer and go to the depot and re-route optimally the remaining customers. We propose flow models that assume at most a single failure in the route. The resulting two level stochastic programs are implemented and run with JuMP using Gurobi.

■ SB34

CC- Room 603

Derivative Free and Surrogate-Model Based Optimization

Sponsored: Optimization/Global Optimization

Sponsored Session

Chair: Hugh Medal

1 - Complex Decision Making in Experimental Materials Science

Soojung Baek, University at Buffalo, Buffalo, NY, United States, soojungb@buffalo.edu, Kristofer Reyes

The Materials Science community has increasingly turned to Bayesian Optimization (BO) to assist in the search for Materials design parameters that optimize material properties. In many settings, the experimentation process imposes constraints that BO does not adequately model, resulting in process inefficiencies. We outline such constraints and illustrate more fluent modeling of experimental state using Markov Decision Processes. We show, through numerous examples, how this modeling, along with the Monte Carlo Tree Search (MCTS) leads to better informed decisions in experimental material science.

2 - Bayesian Optimization for Peptide Design

Peter Frazier, Cornell University, School of Operations Research, and Information Engineering, Ithaca, NY, 14853, United States, pf98@cornell.edu, Lorillee Tallorin, Jialei Wang, Woojoo E. Kim, Swagat Sahu, Nicolas Kosa, Pu Yang, Matthew Thompson, Michael K. Gilson, Michael D. Burkart, Nathan C. Gianneschi

We describe an application of Bayesian optimization in biomaterials. Our goal is to design a peptide to which an enzyme can attach other chemical groups. This allows us to modify, control, and image proteins in which we embed these peptides. Peptides can be tested in a batch in a month-long experiment. We develop a novel algorithm, Peptide Optimization with Optimal Learning (POOL), for recommending batches of peptides that maximize the probability of achieving our design goal. Guided by POOL and using a sequence of month-long laboratory experiments, biochemists at UCSD were able to discover novel short peptides achieving our design goal. This work was recently published in Nature Communications.

3 - Efficient Global Optimization Integrated Stochastic Programming Framework for Reliability-based Design Optimization

Tanveer Hossain Bhuiyan, University of Tennessee, Knoxville, Knoxville, TN, United States, tbhuiyan@vols.utk.edu, Hugh Medal

This paper studies a reliability-based design optimization problem where the product design variables affect the probability distribution of the quality of different components of the product. We model this problem as a stochastic program with endogenous uncertainty where the first-stage selects the design variables for individual components and the second-stage uses a black-box function to evaluate the reliability for the entire system given a realization of the component states. To solve this problem, we use an efficient global optimization approach, exploiting the fact that the relationship between design variables and the probability distribution of component quality is known.

■ SB35

CC- Room 604

Discrete Optimization Meets Machine Learning

Sponsored: Optimization/Integer and Discrete Optimization

Sponsored Session

Chair: Aleksandr M. Kazachkov, QC, H3T1J4, Canada

Co-Chair: Gonzalo Munoz, Montreal, QC, H3T 1N8, Canada

1 - Reward-driven Branching Policies

Giulia Zarpellon, Polytechnique Montreal, Montreal, QC, H3T 1J4, Canada, Jason Jo, Andrea Lodi, Yoshua Bengio

To efficiently solve Mixed-Integer Programming (MIP) problems, solvers trade-off between several aspects of the resolution process, all fundamentally linked to the way the B&B tree is explored and hence to the crucial decision of variable branching. Building on the idea that MIPs share rationales behind what drives a successful search, we identify desirable behaviours within the B&B evolution and translate these properties into reward functions to train branching policies in a reinforcement learning fashion. We compare such reward-driven branching policies to state-of-the-art branching rules and investigate their ability to ultimately being able to solve (never seen) MIP instances.

2 - Boolean Decision Rules via Column Generation

Sanjeeb Dash, IBM Research, Yorktown Heights, NY, 10598, United States, sanjeebd@us.ibm.com, Oktay Gunluk, Dennis Wei

In many machine learning applications, interpretable classification models, such as decision trees, are preferred over more accurate but less interpretable models such as random forests. In this talk, we consider boolean decision rule sets as interpretable models for binary classification. We discuss an integer programming formulation for such models that trades off classification accuracy against rule simplicity, and obtain high-quality classifiers using column generation techniques. Our algorithm dominates some recent alternatives in the accuracy-simplicity trade-off in 8 out of 16 datasets, and produced the winning entry in the 2018 FICO explainable machine learning challenge.

3 - Learning to Branch with Graph Convolutional Neural Networks

Maxime Gasse, Post-doctoral Student, Polytechnique Montréal, Montréal, QC, H3T 1J4, Canada

Combinatorial optimization problems are typically tackled by the branch-and-bound paradigm. We propose a new graph convolutional neural network model for learning branch-and-bound variable selection policies, which exploits the natural variable-constraint bipartite graph representation of mixed-integer linear programs. We train our model via imitation learning on a diversified variant of the strong branching expert rule and demonstrate on a series of synthetic problems that our approach produces policies which can improve upon expert-designed branching rules, and also generalize to instances significantly larger than seen during training.

4 - Learning Optimized Risk Scores

Berk Ustun, Harvard University, Cambridge, MA, United States, berk@seas.harvard.edu, Cynthia Rudin

Risk scores are simple models that let users quickly assess risk by adding and subtracting a few small numbers. These models are widely used in medicine and criminal justice, but difficult to learn from data because they must be calibrated, use small integer coefficients, and obey diverse constraints. We present a new method to learn risk scores from data by solving a discrete optimization problem. We formulate the risk score problem as a MINLP, and present a cutting-plane algorithm to efficiently recover its optimal solution by solving a MIP. We discuss the benefits of our approach by creating risk scores for real world problems.

■ SB36

CC- Room 605

Applications of Robust Optimization in Planning and Scheduling

Sponsored: Optimization/Optimization Under Uncertainty

Sponsored Session

Chair: Chaithanya Bandi, Northwestern University, Evanston, IL, 60208, United States

1 - Free Rides in Dockless Electric Vehicle Sharing Systems

Bobby Nyotta, UCLA Anderson School of Management, Los Angeles, CA, United States, bobby.nyotta.1@anderson.ucla.edu, Fernanda Bravo, Jacob Feldman

We study the effectiveness of free rides as a mechanism to incentivize customer behavior in an electric vehicle sharing system (EVSS) with "dockless" or "free-floating" parking. First, we develop an infinite-horizon dynamic program, and then we build on this formulation to construct a mixed-integer program that determines when to offer based on an intuitive, battery-threshold rule. In a discrete-event simulation model using real EVSS data, we compare the performance of this simple policy and more general discount policies against a Fine-Based policy. Our numerical study shows the free-ride policies dominate on customer utility, but the performance on other dimensions can vary considerably.

2 - Intraday Scheduling with Patient Re-entry and Variability in Patient Behaviours

Minglong Zhou, NUS, Singapore, Singapore, Gar Goei Loke, Chaithanya Bandi, Zi Qiang Glen Liau, Wilson Wang

We consider an intraday scheduling problem where the planner schedules appointment starting times given a sequence of patient appointments. A key feature in our problem is the feedback loop. During a consultation, a patient may be required to go for additional tests, such as X-rays, in different servers. The patient will then go back to the same consultation doctor for a repeated consultation within that day once additional tests are completed. We propose a tractable satisficing framework that satisfices operational constraints and service quality indicators as much as possible. This framework has a strong modelling power and can be applied to realistic job-shop problems in general.

3 - Adaptive Distribution Decision Rule in Resource Allocation Problems

Gar Goei Loke,National University of Singapore, Singapore, Singapore Yun Fong Lim, Peng Wang

In this paper, we consider the resource allocation problem, where the planner can decide upon the resource availability, while attempting to adaptively match the uncertain demand to different supply nodes over a multi-period horizon. Such formulations can be observed in problems such as ride-share fleet re-positioning, and patient management in healthcare. We introduce an adaptive distribution decision rule, which decides on the proportion of jobs awaiting dispatch to each of the possible resource supply pools. Our model has a convex reformulation that can be solved efficiently. We illustrate our model on a maintenance job allocation problem with real world data.

4 - Value of Centralization in Ride-sharing Platforms

Neha Sharma, Kellogg School of Management, Evanston, IL, United States, neha.sharma@kellogg.northwestern.edu, Chaithanya Bandi

We model a platform that matches riders and drivers present on multiple nodes of network. We study the value of centralization (VoC) of the supply for such a ride sharing platform. Since transportation systems are dependent on the road layout of the cities, we study the impact of topology of the network on the VoC. We specifically consider two common urban road layouts: tree and radial network. Further, we investigate how network characteristics like the number of providers, capacity and Gini coefficient impact the VoC for the ride sharing platform.

■ SB37

CC- Room 606

Optimization Under Uncertainty

Sponsored: Optimization/Optimization Under Uncertainty

Sponsored Session

Chair: Ming Zhao, Houston, TX, 77204, United States

1 - Spatial Homogeneity Pursuit of Regression Coefficients for Large Datasets

Huiyan Sang, Associate Professor, Texas A&M University, College Station, TX, United States, huiyan@stat.tamu.edu

Spatial data arises from the research of diverse disciplines. In this talk, we consider a varying coefficient regression model to study the clustered relationship between responses and covariates. In particular, tree-based regularization methods will be developed to encourage spatial homogeneity between regression coefficients at neighboring locations. We will design efficient penalized optimizations to implement the proposed models. We also study the theoretical properties concerning the behavior of the regularization methods. Finally, the performance of the proposed methods is tested with simulation studies and applied to real-life applications.

2 - A Structure Exploiting Branch-and-bound Algorithm for Mixed-integer Model Predictive Control

Pedro Hespanhol, UC Berkeley, San Francisco, CA, 94103, United States, pedrohespanhol@berkeley.edu, Rien Quirynen, Stefano Di Cairano

Mixed-integer model predictive control (MI-MPC) requires solving a mixed-integer quadratic program (MIQP) at each sampling instant under strict timing constraints, where some state/control variables can only assume a discrete set of values. We use the problem structure of MI-MPC in order to provide a branch-and-bound algorithm that can exploit the block-sparse optimal control structure of the problem, and which can also be warm started by propagating information from branch-and-bound trees and solution paths at previous time steps. We illustrate the computational performance of the proposed algorithm and compare against current state-of-the-art solvers for multiple MPC case studies.

3 - Efficient Stochastic Algorithms for Solving Two-player Games

Aaron Sidford, Stanford University, Stanford, CA, United States

In this talk I will present several results on designing more efficient algorithms for solving a variety of structured two-player games. In particular, I will discuss how to design more time and sample-efficient algorithms for solving both bilinear saddle point problems and zero-sum two-player stochastic games (the two-player generalization of MDPs). This talk will feature a variety of tools in sampling, variance-reduction, and iterative method design of hopefully broader utility in building robust optimization procedures.

4 - How Good Are Default Investment Policies in Defined Contribution Plans?

Bernardo Kulnig Pagnoncelli, Universidad Adolfo Ibanez, Diagonal Las Torres Santiago, 7910000, Chile, bernardo.pagnoncelli@uai.cl, David Morton, Daniel Duque

Defined contribution (DC) pension plans have been gaining ground in the last 10-20 years as the preferred system for many countries and agencies, both private and public. The central question for DC plans is how to invest the money in order to reach the participant's retirement goals. Given the financial illiteracy of the general population, it is common to offer a default policy for members who do not actively make investment choices. Using data from the Chilean system, we propose an investment model using stochastic dynamic programming and compare the results with the default policy under a wide variety of objectives.

■ SB38

CC- Room 607

Special Session: A Unified Framework for Optimization under Uncertainty

Sponsored: Optimization/Optimization Under Uncertainty

Sponsored Session

Chair: Warren B. Powell, Princeton University, Princeton, NJ, 08544, United States

1 - Part 1: The Unified Modeling Framework with Applications

Warren B. Powell, Princeton University, Dept of Operations Research and Financial Engr., Princeton, NJ, 08544, United States, powell@princeton.edu

The first stop in solving any sequential decision problem under uncertainty is modeling. We offer a unified modeling framework that consists of five components: state variables, decision variables, new information, the transition function and the objective function, where the objective function is always optimizing over policies. We illustrate this framework in a variety of applications from pure learning problems (also known as bandit problems), to stochastic search, to a range of applications in energy, transportation, health and e-commerce. Key elements involve proper modeling of state variables, modeling different types of uncertainty, and the handling of policies.

2 - Part 2: Modeling Uncertainty and Adaptive Learning

Warren B. Powell, Princeton University, Dept of Operations Research and Financial Engr., Princeton, NJ, 08544, United States, powell@princeton.edu, Saeed Ghadimi, Hugo P. Simao

The next step in the modeling process is identifying and modeling different forms of uncertainty. This is the most overlooked dimension of stochastic optimization, yet is arguably the most important. I will illustrate the different ways that uncertainty can enter a model, and strategies that I have found useful in my own work for modeling uncertainty. I will then identify five classes of adaptive learning problems that arise in stochastic optimization, and review some methods that we have found useful in our own work.

3 - Part 3: Designing Policies I: The Policy Search Class

Warren B. Powell, Princeton University, Dept of Operations Research and Financial Engr., Princeton, NJ, 08544, United States, powell@princeton.edu

There are two fundamental approaches for designing policies: the policy search class, which searches over parameterized classes of policies to find those that work well over time, and the lookahead class, where policies are designed by approximating the impact of a decision on the future. In this part of the talk, I will focus on two strategies in the policy search class: policy function approximations (PFAs) and cost function approximations (CFAs). These are the approaches most widely used in practice because they are the simplest, but the price of simplicity is tunable parameters, a topic I will address.

4 - Part 4: Designing Policies II: The Lookahead Class

Warren B. Powell, Princeton University, Dept of Operations Research and Financial Engr., Princeton, NJ, 08544, United States, powell@princeton.edu

The lookahead class has attracted the most interest from the research community using names such as stochastic programming, dynamic programming and ``model predictive control" (rolling horizon procedures). I will introduce the idea of a lookahead model, and review five ways to approximate these. I will then cover topics such as approximate dynamic programming/reinforcement learning, Monte Carlo tree search, and stochastic programming (briefly). I will close by discussing hybrid strategies such as a parameterized deterministic lookahead that combines the principles of lookahead and policy search (a powerful idea that is widely used in practice).

■ SB39

CC- Room 608

Problem Solving Competition

Sponsored: Railway Applications

Sponsored Session

Chair: Xuesong Zhou, Arizona State University, Tempe, AZ, 85281, United States

Co-Chair: Andrea Leticia Arias, BNSF Railway, Fort Worth, TX, 76244, United States

1 - Railway Applications Section Problem Solving Competition

Andrea Leticia Arias, BNSF Railway, 3945 shiver road, Fort Worth, TX, 76244, United States

This session is reserved for the finalists of the 2019 RAS Problem Solving Competition: "Integrated Train Blocking and Shipment Path Optimization". The presenters and their abstracts will be determined the Judging Committee by late September. More information about the competition is available at https://connect.informs.org/railway-applications/awards/problem-solving-competition

2 - A New Mixed Integer Programming Model for the Integrated Train Blocking and Shipment Path Optimization Problem

Vahid Famildardashti, Cirrelt, Montreal, QC, H3W1W6, Canada, Mohammad Reisi-Nafchi, Pouria Arsalani

An arc-based Mix Integer Programming (MIP) model is presented to solve the Integrated Train Blocking and Shipment Path optimization problem. No linear MIP model has been presented for this problem in the literature. We developed a linear MIP model for this problem and reported and analyzed the computational results. Three different problem instances provided by RAS2019 for this problem were solved using GUROBI optimizer.

3 - Integrated Train Blocking and Shipment Path Optimization (TBSP)

Tsung-Han Wang, National Cheng Kung University, Hsinchu City, Taiwan, Yen-Tzu Yueh, Yen-Wei Chen

Viewing each OD shipment as a commodity, this problem becomes a special min-cost OD multicommodity network design problem, where the bundle constraints consider two more types of node capacities. Starting with good initial multicommodity flows, our two integer programs cover all constraints with good efficiency and effectiveness. The innovative inverse shortest path heuristic helps good estimation on the dual variables of bundle constraints. A column generation scheme is also proposed.

4 - Integrated Train Blocking and Shipment Path Optimization

Karen Angulo Diaz, Universidad de los Andes, Bogotá, 110111, Colombia, Oscar Guaje Acosta, Daniel Suarez Bayona

We propose a methodology that solves the TBSPP based on three stages. First, we propose a novel formulation based on a multi-commodity network flow problem to generate an initial set of routes. Second, we greedily augment the set of routes seeking diversity in the available routes. Finally, we solve an MIP that enforces feasibility using the set of available routes. We achieve good solutions in acceptable computational time.

■ SB40

CC- Room 609

Optimization for Data Science

Sponsored: Optimization/Nonlinear Programming

Sponsored Session

Chair: Ying Cui

1 - An Asymptotically Superlinear Convergent Semismooth Newton Augmented Lagrangian Method for LP

Xudong Li, Fudan University, Shanghai, China, lixudong@fudan.edu.cn, Defeng Sun, Kim-Chuan Toh

Powerful interior-point methods (IPM) based commercial solvers have been hugely successful in solving large-scale linear programming problems. Unfortunately, the natural remedy, although can avoid the explicit computation of the coefficient matrix and its factorization, are not practically viable due to the inherent extreme ill-conditioning of the large scale normal equation arising in each interior-point iteration. To provide a better alternative choice for solving large scale LPs with dense data, we propose a semismooth Newton based inexact proximal augmented Lagrangian method.

2 - Consistency of Stationary Solutions of Coupled Nonconvex Nonsmooth Empirical Risk Minimization

Zhengling Qi, University of North Carolina at Chapel Hill, Chapel Hill, NC, United States, Ying Cui, Yufeng Liu, Jong-Shi Pang

This paper establishes the statistical consistency of stationary solutions of a class of coupled nonconvex and nonsmooth empirical risk minimization problems, whose optimal solutions are computationally elusive in general. The considered model covers a broad range of emerging applications in machine learning such as two-hidden-layer neural networks. Our derived results show that the sharpness of stationary solutions (directionally stationary points) at the empirical level is preserved at the population level, which demonstrates the necessity of computing sharp stationary solutions in practice.

3 - Power k-Means Clustering: Majorization-Minimization Avoids Local Minima

Jason Xu, Assistant Professor, Duke University, Durham, NC, United States, Kenneth Lange

We propose an alternative to Lloyd's classic clustering algorithm that retains its simplicity but mitigates its tendency to get trapped in local minima. Our method embeds the k-means objective in a family of similar, better behaved problems with fewer local minima. The previously discovered k-harmonic means algorithm coincides with one point along this continuum. Power k-means anneals its way toward the solution by way of majorization-minimization (MM), sharing the appealing descent property and low O(nkd) complexity of Lloyd's algorithm. We demonstrate its merits in simulated and real data examples.

■ SB41

CC- Room 610

Algorithmic Foundations for Large-Scale Machine Learning

Sponsored: Optimization/Linear and Conic Optimization

Sponsored Session

Chair: Xudong Li

1 - Reinforcement Leaning in Feature Space: Matrix Bandit and Regret Bound

Lin Yang, Princeton, Princeton, NJ, United States

We study the regret-minimization problem of reinforcement learning for an episodic Markov decision process. We propose an algorithm that leverages the linear bandit and dynamic programming to learn a low-dimensional representation of the transition matrix as well as to do exploration that balances exploitation. We show that our algorithm achieves a regret bound ${O}\big(d^2\sqrt{H^3T\log T}\big)$, where d is the dimension of the features. To the best of our knowledge, for reinforcement learning with linearly additive features, this is the first regret bound that is simultaneously near-optimal in time, polynomial in the planning horizon and the feature dimension.

2 - High Dimensional Tensor Regression Analysis

Anru Zhang, University of Wisconsin-Madison, Madison, WI, 53562, United States, anruzhang@stat.wisc.edu

The past decade has seen a large body of work on high-dimensional tenors that arise in numerous applications and are applied to many statistical problems. The tensor often comes with natural low-rank or sparsity structure. How to exploit such structure for tensors poses new statistical and computational challenges.In this talk, we introduce a novel procedure for low-rank tensor regression to address these challenges. We show that our method is sharply minimax optimal under low-rank Tucker assumptions. Further, we show the proposed procedure achieves comparable mean-squared error performance to existing state-of-the-art methods whilst having substantial storage and run-time advantages.

3 - High-dimensional Principal Component Analysis with Heterogeneous Missingness

Ziwei Zhu, University of Cambridge, Cambridge, United Kingdom

I will focus on the effect of missing data in PCA. Under a homogeneous missingness mechanism, the leading eigenspaces of a Hadamard reweighted sample covariance matrix are shown to achieve the minimax optimal rate up to logarithmic factors. Under the incoherence assumption, we can embrace much more flexible missingness mechanisms. We derive the statistical rate of the Hadamard-reweighting-based estimator under arbitrary deterministic observation regime. We then feed this estimator to a new tuning-free iterative algorithm called primePCA. We show that under the noiseless setting, primePCA achieves exact recovery of the true leading eigenspaces with geometric convergence.

4 - On the Equivalence of Inexact Proximal ALM and ADMM for a Class of Convex Composite Programming

Xudong Li, Fudan University, Shanghai, China, lixudongkeer@gmail.com

In this talk, we show that for a class of linearly constrained convex composite optimization problems, an (inexact) symmetric Gauss-Seidel based majorized multi-block proximal alternating direction method of multipliers (ADMM) is equivalent to an inexact proximal augmented Lagrangian method (ALM). This equivalence not only provides new perspectives for understanding some ADMM-type algorithms but also supplies meaningful guidelines on implementing them to achieve better computational efficiency.

■ SB42

CC- Room 611

Network Design Models and Algorithms

Contributed Session

Chair: Tan C. Miller, Rider University, Morris Plains, NJ, 07950, United States

1 - Optimal Deployment of Charging Lanes and Charging Stations for Electric Vehicles in Transportation Networks

Xiasen Wang, University of Washington, Seattle, WA, United States, wxiasen@gmail.com

With the rapid development of charging-while-driving technology, the deployments of charging lanes and direct current fast chargers (DCFC) inevitably affect the charging and route choices decisions of battery electric vehicle (BEV) drivers. This study builds a two-level optimization framework to solve the deployment problem of the two different charging facilities and the traffic assignment problem simultaneously. We first build a user equilibrium model to assign the traffic on the road network given the location of the two charging methods. we further formulate the deployment plan as a mathematical program.

2 - Extreme-point Tabu Search Heuristics for Fixed-charge Generalized Network Problems

Angelika Leskovskaya, Visiting Professor of Practice, Southern Methodist University, Dallas, TX, United States, aleskovs@smu.edu, Richard Barr

While researchers have studied generalized network flow problems extensively, the powerful addition of fixed charges on arcs has received scant attention. The proposed network-simplex-based algorithm efficiently exploits the quasi-tree basis structure, utilizes a candidate list, a tabu search, and a diversification phase to solve FCGT problems. Computational testings demonstrate heuristic's effectiveness in terms of speed and quality of solutions. Comparisons with a state-of-the-art solver, CPLEX, show that the extreme-point tabu search algorithm runs, on average, five orders of magnitude faster and produces solution values within 2.2% of the optimal solution reported by CPLEX.

3 - A Comprehensive Collaborative Agreement for Cost-effective Vessel Scheduling in Liner Shipping

Maxim A. Dulebenets, Florida A&M University-Florida State University, Tallahassee, FL, 32311, United States, mdlbnets@gmail.com, Junayed Pasha, Masoud Kavoosi, Olumide Abioye

Without effective vessel schedules liner shipping companies may incur substantial monetary losses. This study proposes a new collaborative agreement for vessel scheduling, based on which the liner shipping company is offered multiple vessel arrival time windows, start and end times for each time window, and multiple handling rates during each time window by the marine container terminal operator to at each port of the liner shipping route. The proposed collaborative agreement is evaluated against the ones, which were previously presented in the liner shipping literature.

4 - A Medical Device Network Design Model

Tan C. Miller, Director of Global Supply Chain Management Program, Rider University, Morris Plains, NJ, United States, tanjean@verizon.net, Renato E. de Matta, Emmanuel Peters

We propose and develop new methodologies utilizing mathematical optimization and simulation models to jointly improve the design of the physical networks, and to enhance the inventory management practices of the medical device industry.

■ SB43

CC- Room 612

Adaptive Sampling for Optimization under Uncertainty

Sponsored: Computing

Sponsored Session

Chair: Yongjia Song, Clemson University, Clemson, SC, 29634, United States

1 - Enhanced Balancing of Bias-variance Tradeoff in Stochastic Simulation

Henry Lam, Columbia University, New York, NY, 10027, United States, henry.lam@columbia.edu

Biased stochastic estimators, such as finite-differences for noisy gradient estimation, often contain tuning parameters that balance impacts from the bias and the variance. While the optimal order of these parameters in terms of the simulation budget can be readily established, the precise best values depend on model characteristics that are typically unknown in advance. We investigate a minimax risk framework to construct new estimators by combining simulation runs on sequences of tuning parameter values, such that the estimators consistently outperform a given tuning parameter choice in the conventional approach, regardless of the unknown model characteristics.

2 - ASTRO for Derivative-based Smooth Stochastic Optimization

Daniel Vasquez, Purdue University, West Lafayette, IN, United States, dvasque@purdue.edu

Trust-region algorithms have proven to be a stable and efficient class of algorithms to solve optimization problems having smooth objective functions. We present Adaptive Sampling Trust-Region Optimization (ASTRO) for derivative-based stochastic optimization settings, where the objective function and it's gradient are observed with stochastic error, e.g., using a dataset or Monte Carlo. We detail ASTRO, clarify its achieved complexity rates especially in relation with two other stochastic trust-region algorithms, and present extensive numerical results.

3 - Distributionally Robust Stochastic Dual Dynamic Programming

Daniel Duque Villarreal, Northwestern University, Evanston, IL, United States, danielduque@u.northwestern.edu, David Morton

We consider a multi-stage stochastic linear program that lends itself to solution by stochastic dual dynamic programming (SDDP). In this context, we consider a distributionally robust variant of the model with a finite number of realizations in each stage, and distributional robustness is with respect to the probability mass function governing candidate realizations. We describe a computationally tractable variant of SDDP to handle this model using the Wasserstein distance to characterize distributional uncertainty.

4 - Joint Chance-constrained Programs and Intersection of Mixing Sets Through a Submodularity Lens

Dabeen Lee, Institute for Basic Science, Daejeon, Korea, Republic of, Fatma Kilinc-Karzan, Simge Kucukyavuz

Intersection of mixing sets with common binary variables arise when modeling joint linear chance-constrained programs with random right-hand sides and finite sample space. In this talk, we first establish a strong and previously unrecognized connection of mixing sets to submodularity. This viewpoint enables us to unify and extend existing results on polyhedral structures of mixing sets. Then we study the intersection of mixing sets with common binary variables and also linking constraint lower bounding a linear function of the continuous variables. We propose a new class of valid inequalities and characterize when this new class along with the mixing inequalities are sufficient to describe the convex hull.

■ SB44

CC- Room 613

Routing Problems and Applications

Sponsored: Computing

Sponsored Session

Chair: Joshua T. Margolis, Clemson University, Clemson, SC, 29631, United States

1 - Optimizing the Response for Arctic Mass Rescue Events

Mustafa Can Camur, Rensselaer Polytechnic Institute, Troy, NY, 12180, United States, Thomas C. Sharkey, Martha Grabowski, Clare Dorsey

We study a mass rescue model containing dynamic logistics decisions for a large-scale maritime evacuation in the Arctic. An integer linear programming model is proposed with the objectives of minimizing the impact of the event on the evacuees and the average evacuation time. We capture the unique aspects of this environment, including the fact that evacuees will flow from the ship through small Arctic communities while support resources will flow from southern Alaska to support them. We discuss experimental results and the impact of decomposition algorithms on runtimes.

2 - Cost Effective Regional Evacuation Network Design Problem under Uncertainty

Nadere Mansouri, Southern Methodist University, Dallas, TX, 75231, United States, Halit Uster

We pose and analyze a strategic evacuation network design problem which determines open shelter locations and evacuee routes (road segments) under uncertainty in the number of people evacuating the sources. We propose a chance-constrained stochastic programming model and present an efficient Benders Decomposition based approach for its solution. We also apply our methodology to solve test instances developed based on real data from Central Texas.

3 - Routing Plans in the Wake of Hurricanes: Practitioner Guided Scenarios

Andrew Alseth, University of Arkansas, Fayetteville, AR, United States, awalseth@email.uark.edu, Ashlea Bennett Milburn

Despite the growing availability of real-time data on road networks, road network availability during and after disasters changes rapidly. This affects the ability to bring supplies to points of distribution (PODs) and other time-sensitive tasks. We investigate the application of the Canadian Traveler's Problem (CTP) to model scenarios developed from interviews of emergency managers and logisticians in government, private companies, and non-profit agencies. Several routing strategies are compared for agents acting in a network with stochastic edge status.

4 - A Multi-vehicle Covering Tour Problem with Speed Optimization

Joshua T. Margolis, PhD Candidate, Clemson University, Clemson, SC, 29631, United States, jtmargo@clemson.edu, Yongjia Song, Scott J. Mason

The multi-vehicle covering tour problem with time windows (MCTPTW) aims to construct a set of maximal coverage routes for a fleet of vehicles that observe a secondary set of sites given a fixed time schedule, coverage requirements, and energy restrictions. The problem is formulated as a mixed-integer second-order cone program and is an extension of both the multi-covering tour problem and the vehicle routing problem with time windows under energy constraints. We study a special case of the proposed model and develop a label correcting algorithm to solve its Lagrangian relaxation problem, which exploits the combinatorial structure exhibited by an optimal solution to the Lagrangian relaxation.

■ SB45

CC- Room 614

Advances in Nonlinear Programming

Sponsored: Optimization/Nonlinear Programming

Sponsored Session

Chair: Miju Ahn, Southern Methodist University, Dallas, TX, 75205, United States

1 - Plug-and-play: Use Trained Networks in Optimization with Provable Convergence

Wotao Yin, University of California, Los Angeles, Los Angeles, CA, United States, Ernest Kang Ryu, Jialin Liu, Sicheng Wang, Xiaohan Chen, Zhangyang Wang

Plug-and-play (PnP) is an optimization framework that integrates pre-trained deep networks into ADMM and other proximal optimization algorithms. An advantage of PnP is that one can use pre-trained networks when there is not sufficient data for end-to-end training. Although PnP has exhibited great empirical results, theoretical analysis addressing even the basic question of convergence has been insufficient. We establish convergence of PnP-FBS and PnP-ADMM. Finally, we present experimental results that validate the theory.

2 - Algorithmic Development for Computing B-stationary Points of a Class of Nonsmooth DC Programs

Zhaosong Lu, Simon Fraser University, Burnaby, BC V5A 1S6, BC, Canada, zhaosong_lu@sfu.ca

In this talk we first consider a class of unconstrained nonsmooth DC programs in which the concave summand of the objective is an infimum of possibly infinitely many smooth concave functions. We propose some algorithms by using nonmonotone linear search and extrapolation techniques for possible acceleration for them, and analyze their global convergence, sequence convergence and also iteration complexity. We then consider a class of DC constrained nonsmooth DC programs. We propose a penalty method for solving them and show that it converges to a B-stationary point under much weaker assumptions than those imposed in the literature. This is joint work with Zhe Sun and Zirui Zhou.

3 - Multi-composite Nonconvex Optimization for Training Deep Neural Networks

Ziyu He, University of Southern California, Los Angeles, CA, United States, ziyuhe@usc.edu, Ying Cui, Jong-Shi Pang

We present a novel deterministic algorithmic framework that enables the computation of a directional stationary solution of the empirical deep neural network training problem. The proposed approach combines the methods of exact penalization, majorization-minimization, gradient projection with enhancements, and the dual semismooth Newton method, each for a particular purpose in an overall computational scheme. Numerical results from a MATLAB implementation demonstrate the effectiveness of the framework for solving reasonably sized networks with a modest number of training samples.

4 - Bounds on the Stationary Solutions of Sparse SAA Problems

Miju Ahn, Southern Methodist University, Dallas, TX, 75205, United States, mijuahn@gmail.com

In many applications, predictive modeling with nonconvex sparsity functions is practiced to minimize the empirical prediction error through sample average approximation. We study the properties of the stationary solutions of such problems. We derive bounds for the distance between the stationary solutions and a vector that is possibly the ground truth, and the model predictions produced by them. Furthermore, the inclusion relationships between their support sets of nonzero valued indices are studied. Some of the results are generalization of the existing theory shown for the specialized problem of L1-norm regularized least squares minimization for linear regression.

■ SB46

CC- Room 615

Joint Session TSL/ITS/Practice Curated: Large-scale Data Analytics for ITS – Part 2

Sponsored: Transportation Science & Logistics/Intelligent Transportation Systems (ITS)

Sponsored Session

Chair: Zhen Qian, Carnegie Mellon University, Pittsburh, PA, 15213, United States

Chair: Wei Ma

1 - Data Driven Approach for Calibrating BPR Function as a Queueing Model

Qixiu Cheng, Southeast University, Nanjing, 210096, China, qixiu.cheng@seu.edu.cn, Xuesong Zhou, Zhiyuan Liu

Emerging urban transportation applications need to address a wide range of challenges, including highly dynamic traffic conditions and complex demand-supply interaction. This talk aims to establish analytical equivalence between the BPR travel time function and deterministic queuing models, in order to develop a theoretically rigorous and data driven approach for large-scale traffic system calibration.

2 - Extracting Trips from Multi-Sourced Data for Mobility Pattern Analysis: An App-Based Data Example

Feilong Wang, Department of Civil and Environmental Engineering, University of Washington, Seattle, WA, United States

Passively-generated data need to be processed to extract trips. Most existing methods rely on data generated via a single positioning technology such as GPS or triangulation through cellular towers (single-sourced data), and methods to extract trips from data generated via multiple positioning technologies (or, multi-sourced data) are absent. Generated using multiple technologies (e.g., GPS, cellular network- and WiFi-based), multi-sourced data contain high variances in their temporal and spatial properties. Consequently, methods for single-sourced data are not applicable to multi-sourced data. Here, a DCI framework is proposed and tested.

3 - Identifying Network Characteristics of Bike-sharing System and Station Usage: Chicago Divvy Bike Case Study

Yuhan Zhou, Northwestern University, Evanston, IL, United States, yuhanzhou2020@u.northwestern.edu, Ying Chen, Hani S. Mahmassani

Divvy bike in Chicago is the second largest bike sharing system in the US. In this study, longitudinal data from 2014 to 2018 is used to investigate properties of bike-sharing trips and station usage, as well as how these attributes change as Divvy bike system are expanding from 300 stations to more than 600 stations. Network analysis metrics are adapted to exhibit connectivity among bike stations and identify patterns of bike-sharing activities in Chicago.

4 - A Methodological Framework for Data-Driven Performance Evaluation of Subway Operations Using Mobile Data

Abdullah Kurkcu, Research Associate, New York University, Brooklyn, NY, United States, ak4728@nyu.edu, Kaan Ozbay, Hisashi Kanamori, Daichi Ayado

For NYCT's subway operations to be operated efficiently and resiliently, it is important to have visibility into how the population interfaces with the system. Unfortunately, this information would not be readily available if NYCT relies only on existing datasets. One additional data source is the WiFi association data collected by TransitWireless. The communications company owns and operates 160 miles of fiber across 282 underground subway stations. They collected data on approximately 120 million passengers in the last year, which constitutes 7% of total annual passengers. With this sample size, much can be inferred about transit operations that can be put into practice fairly quickly.

■ SB47

CC- Room 616

Transportation, Operations II

Contributed Session

Chair: Sergey Naumov, MIT Sloan School of Management, Cambridge, MA, 02142, United States

1 - Dynamic Optimal Approach for An Electric Taxi Fleet's Charging and Order-service Schemes

Kaize Yu, University of Electrolic Sicence and Technology of China, Chengdu, China, 845557030@qq.com, Pengyu Yan

This paper addresses a charging and order-service scheme problem for an electric Taxi (ET) fleet operated by an e-hailing platform. The long charging time significantly affects the fill rate of orders and the incomes of the fleet. The platform as a centralized manager needs to determine the charging and order-service scheme of all ETs for each period based on the real-time information of a charging station, the remained powers of ETs and the coming orders. The problem is formulated as a multiple-period stochastic programming model to maximize the total revenue and a rolling horizon approach is proposed. The experimental results demonstrate the effectiveness of the proposed dynamic decision approach.

2 - Integrated Planning of Charging Stations and PV Power Plants with Time-dependent Pricing for Electric Vehicles

Zhixiong Luo, Tsinghua University, Beijing, China, luozx18@mails.tsinghua.edu.cn, Fang He, Xi Lin, Yanni Yang, Meng Li

This study jointly designs charging stations and photovoltaic (PV) power plants with time-dependent electricity price to better manage the coupling of network traffic and power flow carried by electric vehicles (EV). We first propose an extend label-setting algorithm to solve the routing choice of EV drivers. Then a variational inequality and a mixed integer second order cone programming are formulated to respectively model the EV traffic equilibrium and the optimal power flow. Based on the above models, we formulate a bi-level model and solve it by a surrogate-based optimization (SBO) algorithm. Numerical studies show the efficiency of the SBO algorithm and the benefits of jointly planning.

3 - The Urban Recharging Infrastructure Design Problem with Electric Taxi Demand Prediction Using Convolutional Neural Network

Seong Wook Hwang, Assistant Professor, Hongik University, Sejong-si, Korea, Republic of, swhwang@hongik.ac.kr, Sunghoon Lim

In this study we first design a convolutional long short-term memory model that predicts taxi drop-off and pick-up demands for time periods in urban areas. Then, based on the predicted taxi demand in drop-off and pick-up hotspots, a mathematical model is proposed to optimize the location of recharging stations so as to minimize the locating cost of stations and delay cost for recharging service.

4 - Capacitated Optimization Problems for Taxi vs. Uber Platforms with Gasoline vs. Electric Fleets

Sang Jin Kweon, Ulsan National Institute of Science and Technology, Ulsan, Korea, Republic of

Taxi platforms are interested in deploying electric fleets for operational benefits compared to gasoline fleets. At the same time, Uber and any other Uber-like online mobile platforms are emerging to match riders with drivers. They are also excited to deploy electric fleets for ride service. While electric fleets are less expensive to operate, they are more expensive to acquire, and besides, they have less capacity than gasoline fleets in terms of ride service due to long time to charge their batteries. In this talk, we study which platform is more favorable to deploy electric vehicles.

5 - Hailing Rides Using On-demand Mobility Platforms: What Motivates Consumers to Choose Pooling?

Sergey Naumov, Assistant Professor, Penn State Smeal College of Business, State College, PA, United States, snaumov@sloan.mit.edu, David Keith

Carpooling, in which multiple passengers share a single vehicle, provides opportunities to reduce negative externalities of driving. While historically, pooling has been unpopular in the U.S., partly due to the inconvenience of finding fellow commuters, recently, it has been of renewed interest, because ride-hailing platforms automate rider matching and offer pooled rides at relatively low prices. As automated vehicles are expected to further reduce trip costs, will people pool even more? We estimate consumer preferences and show that counter-intuitively the share of pooled rides will shrink, rather than increase, with lower driving costs, but a significant income effect exists.

■ SB48

CC- Room 617

Freight Transportation Resilience and Economic Impacts

Sponsored: Transportation Science & Logistics/Freight Transportation & Logistics

Sponsored Session

Chair: Mohamad Darayi, Pennsylvania State University-Great Valley, Malvern, PA, 19355, United States

1 - Planning for Recovery under Uncertainty in a Multi-modal Freight Transportation Network

Majid Eskandarpour, Ecole des Mines de Nantes, Nantes, France

Freight transportation network recovery is mainly affected by bad weather conditions and involved uncertainties in transfer time of work crew and equipment, and the required time to recover a network component. This work proposes a stochastic MILP model and a simulation-based optimization algorithm to find the best routes to transfer the crew for network restoration in uncertain conditions in order to minimize the economic loss.

2 - A Systematic Framework to Analyze Freight Transportation Resilience Considering Economic Impacts

Mohamad Darayi, Pennsylvania State University-Great Valley, Engineering Division, Malvern, PA, 19355, United States

Freight transportation infrastructure, including ports, intermodal stations, interstate highways, and railways, plays an important role in the economic vitality of states, regions, and the broader country. This work proposes a systematic framework to analyze freight transportation resilience by (i) evaluating vulnerability of the interdependent system of freight infrastructure and economic sectors, (ii) seeking strategies to allocate a limited budget to harden the system, and (iii) assessing value of information in decision making under uncertainty.

3 - Investing in Freight Transportation Infrastructure Resilience Considering Economic Impacts

Devendra Prakash Jaiswal, Pennsylvania State University-Great Valley, Malvern, PA, United States, dxj323@psu.edu, Mohamad Darayi

The functionality of a multi-modal freight transportation network is threatened by disruptive events that can disable the capacity of the network to enable flows of commodities in portions of nodes and links. This research proposes a simulation-based optimization model to devise budget allocation under uncertainty to enhance the network resilience via network hardening and/or network completion strategies.

4 - Restoration Routing Problem with Path Selection

Nazanin Morshedlou, Mississippi State University, Starkville, MS, United States, nazanin.morshedlou@ou.edu, Kash Barker

We introduce two mixed integers (MIP) restoration problems that schedule a set of disrupted components to each restoration crew. The model interconnects a routing network with the restoration problems through which restoration crews are dispatched, from depots, towards disrupted components. To approach the formulation to reality, we propose a path selection algorithm to stochastically choose shortest paths between each pair of disrupted locations. However, the shortest path between each pair of locations changes due to the nonconvex behavior of commuters and restoration schedule. The proposed model tries to incorporate the stochastic shortest path selection problem into the model.

5 - A Novel Hurricane Classification Method to Quantify Economic Impacts of Hurricanes

Vera Wendler-Bosco, University of Oklahoma, Norman, OK, United States, Charles D. Nicholson

The Saffir-Simpson Hurricane Scale (SSHS) is the most commonly used classification method for hurricanes. Even though widely used and well-established, the SSHS presents a clear shortcoming: it is not able to convey the economic impacts of hurricanes to the affected region. A high SSHS classification scale does not necessarily means a highly destructive and costly hurricane. Similarly, a hurricane with a low SSHS classification does not necessarily mean a weak hurricane. A novel hurricane classification method was developed, focusing on the potential monetary damage that a hurricane can cause when reaching the coast.

■ SB49

CC- Room 618

Joint Session TSL/URB/Practice Curated: Data Analytics in Transportation Operations

Sponsored: Transportation Science & Logistics/Urban Transportation

Sponsored Session

Chair: Isil Koyuncu, The University of Alabama, Tuscaloosa, AL, 35487, United States

Co-Chair: Sevgi Erdogan, University of Maryland, Silver Spring, MD, 20910, United States

1 - Using Analytics to Assess Travel Reliability in Public Transportation Networks

Michael Redmond, University of Iowa, Iowa City, IA, 52246, United States, michael-a-redmond@uiowa.edu, Ann Melissa Campbell, Jan Fabian Ehmke

Urban travel planning applications are increasing in popularity as travelers look to utilize technology when planning their trips. However, the research and applications in this area often only consider deterministic and scheduled travel time through the network. This presentation will focus on using stochastic travel time distributions on the edges of public transportation networks to give travelers reliability of their itineraries. This research helps capture how transfers and variance in travel time affect the reliability of an itinerary. The presentation will also explore the concept of a backup itinerary in case a transfer is missed.

2 - What Can We Learn About Health Care in Alabama from Analysis of Emergency Medical Services Data?

Abhay Lidbe, University of Alabama, Tuscaloosa, AL, United States, adlidbe@ua.edu, Margaret McNamara, Thomas English, Todd Smith, Nathan Culmer

Maintaining profitability for most rural hospitals has threatened their existence when the county residents bypass local county hospitals and choose distant hospitals. This study investigates variations in EMS response times focusing on the various travel time components (e.g., travel to scene, travel between scene and destination facility, wall time, etc.) resulting from such patients' choices. It is proposed that the study could be used to identify opportunities for optimization of EMS response times in both rural and urban areas.

3 - Data-driven Origin-destination Matrix Estimation in Large-scale Integrated Public Transport Systems

Jorge Huertas, Universidad de los Andes, Bogota, Colombia, huertas.ja@uniandes.edu.co, Palacio Alejandro, Marcelo Botero, Lisseth D. Grosso, Carolina Osorio, Andres L. Medaglia, Sergio Cabrales

The OD matrix estimation problem lies at the core of decision making for transport operators worldwide. The OD matrix describes the spatial and temporal distribution of demand and is fundamental to update bus routes and schedules. Bogotá's integrated public transport system consists of a Bus-Rapid Transit system articulated with a bus system. Solely the bus component comprises over 7400 bus stops, 275 services, and 1.6 million trips, we propose a low cost and efficient estimation method for calculating an OD matrix for the bus system incorporating information from smart cards, bus geolocation data, and mobility surveys, among other sources.

4 - No One is Left Behind: Modeling Access to Evacuation Shelters for Low-income Residents

Sevgi Erdogan, Assistant Research Professor, University of Maryland, College Park, MD, 20910, United States, serdogan@umd.edu, Mohammad M. Nejad, Cinzia Cirillo

Natural or man-made hazards that require evacuation put already vulnerable populations in a more precarious situation. Low income residents without vehicles need alternative transportation means to reach shelters. Data from the American Community Survey, US Census, Internal Revenue Services and the National Household Travel Survey are used to generate synthetic population for Anne Arundel County, MD using the copula concept. Geographic locations of low-income residents are identified within each sub-area of the county and their car ownership is estimated with Binomial Logit model. A facility location model is formulated to identify the best shelter for each geographic sub-area.

5 - Exploiting Conventional Vehicles in Green Vehicle Routing

Isil Koyuncu, University of Alabama, Alston Hall 300, Tuscaloosa, AL, 35487, United States, ikoyuncu@crimson.ua.edu, Mesut Yavuz

This talk addresses a family of green vehicle routing problems that incorporates several key modeling aspects such as refueling at customer and non-customer locations. Conventional vehicles, i.e., gasoline or diesel vehicles, are exploited in the heterogeneous green vehicle routing context.

■ SB50

CC- Room 619

Drones for Smart Logistics

Sponsored: Transportation Science & Logistics/Facility Logistics

Sponsored Session

Chair: Mehdi Behroozi, PhD, Northeastern University, Boston, MA, United States

Co-Chair: Mohammad Moshref Javadi, PhD., MIT, Cambridge, MA, United States

1 - A Vehicle Routing Visualization Toolkit for Drones

Chase Murray, University at Buffalo, Dept of Industrial & Systems Engineering, Amherst, NY, 14260-2050, United States, cmurray3@buffalo.edu, Lan Peng

This talk introduces VeRoViz, an open-source vehicle routing visualization package for Python. VeRoViz aims to simplify the process of creating test problems, generating distance matrices, and visualizing the solutions to vehicle routing problems. It consists of a large (and growing) collection of functions. While some of these functions are wrappers for existing APIs, many of the functions represent new capabilities. We discuss the key features of VeRoViz, explain the overall system architecture, and provide some examples that showcase its utility for for drone routing problems.

2 - Same-day Delivery with Deterministic Release Dates and Drones Resupply

Juan C. Pina, Pontificia Universidad Catolica Valparaiso, Valparaiso, Chile, Daniel F. Silva, Alice E. Smith

For several years researchers have studied using drones for last-mile parcel delivery. However, an area that is often neglected, but a natural fit for drone operations is same-day delivery services, where waiting times are key to customer satisfaction. We propose the use of drones to resupply dispatch vehicles while they are en route, assuming order-release times are known at the beginning of the day. We present a MILP formulation that minimizes distribution costs and customer waiting times. We also show a heuristic to find satisfactory solutions in computationally reasonable times.

3 - Several New Results for the Traveling Salesman Problems with Drone

Minh Hoàng Hà, ORLab, VNU University of Engineering and Technology, Hanoi, Viet Nam, minhhoangha.vth@gmail.com

In this presentation, we will discuss the traveling salesman problems with drone in which at a customer location, a truck can launch a drone to service customers, then continue to visit other customers before retrieving the drone at another customer location. Two problems are considered. The first one deals with the case where drone can service only one customer during a flight while in the second one, it can perform multiple deliveries after being launched. We will introduce a new hybrid genetic algorithm for the former. A mixed integer linear programming formulation and a metaheuristic based on Iterated Local Search are presented for the latter.

4 - A Stochastic Multi-criteria Team Orienteering Problem of UAVs Considering Time Window and Charging Stations

Mohammad Dehghanimohammadabadi, Northeastern University, Boston, MA, United States, m.dehghani@neu.edu, Yuanye Ma

Unmanned Aerial Vehicles (UAVs) are a proper transportation option that can directly fly from one node to another without any traffic congestion and extend their flying range by making use of the charging stations. However, the flying range of the UAVs is limited due to battery constraints. A huge additional cost will occur if a UAV runs out-of-charge on the way to its next destination. This paper focuses on an innovated version of Team Orienteering Problem with Time Windows (TOPTW) in which a set of nodes with stochastic rewards need to be visited by a set of homogeneous UAVs. A simheuristic approach is used to solve the problem and maximize the total expected rewards as well as the total coverage area.

5 - Integrated Truck-Drone Vehicle Routing Problem

Patchara Kitjacharoenchai, PhD Candidate, Purdue University, West Lafayette, IN, 47906, United States, pkitjach@purdue.edu, Seokcheon Lee

This research integrates the truck routing problem, drone routing problem and synchronized truck-drone routing problem all together as a single distribution system. The proposed model is a variant of Heterogeneous Fleet Vehicle Routing Problem (HFVRP) with different capacity and traveling range for three types of vehicles: truck, drone, and synchronized truck-drone vehicle. It determinesthe optimal routes of both trucks and drones which minimize the total arrival time of both trucks and drones at the depot after completing the deliveries. The problem can be solved by the formulated mixed integer programming (MIP) for the small size problem.

■ SB51

CC- Room 620

AAS Best Student Presentation Competition II

Sponsored: Aviation Applications

Sponsored Session

Chair: Heng Chen, University of Nebraska-Lincoln, Lincoln, NE, 68588, United States

1 - Frequency Approximations for Two-Stage Location Price Competition

Reed Harder, Dartmouth, Hanover, NH, 03755, United States

In many critical industries, competing firms allocate resources across their networks by deciding service locations and pricing these services. For example, airlines competitively schedule and price flights across many origin-destination pairs. Solving for exact equilibrium service locations and prices can quickly become intractable. However, questions of practical interest are often more concerned with aggregate quantities of service within a market than exact service location decisions. With considerations in mind, we evaluate the effectiveness of approximating location decisions with service frequency decisions in firm profit functions.

2 - A Delayed Column Generation Approach for Solving a Cargo Crew Scheduling Problem

Junhong Guo, University of Michigan-IOE, Ann Arbor, MI, 48109-2117, United States

We develop efficient models and algorithms to construct monthly crew schedules for a cargo airline, where crew pairings are allowed to contain a break in the middle. These pairings should be of appropriate length and workload so as to cover as many flights scheduled in the planning horizon as possible. Allowing a break in the middle can greatly increase the flight coverage, but at tremendous computational cost, as the underlying network becomes extremely dense. We propose a heuristic and an exact algorithm, embedded in a delayed column generation procedure, to address this issue.

3 - Network Revenue Management under a Spiked Multinomial Logit Choice Model

Yufeng Cao, Georgia Tech, Atlanta, GA, 30080, United States, yufeng.cao@gatech.edu

Airlines have long noticed that the cheapest available fare class attracts a disproportionate fraction of demand. Incorporating this phenomenon, we study a network revenue management problem under a spiked multinomial logit (spiked-MNL) choice model, where an airline dynamically adjusts its assortment offered to customers. We formulate the problem as a stochastic dynamic program and study the structure of its optimal policy. We propose a tractable deterministic approximation and show how its solution can be used to construct booking limit heuristics that are near-optimal.

■ SB52

CC- Skagit 1

Data-Driven Assortment and Price Optimization

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Sajad Modaresi, UNC Chapel Hill, Kenan-Flagler Business School, Chapel Hill, NC, 27514, United States

1 - Demand Learning and Dynamic Pricing for Varying Assortments

Kris J. Ferreira, Harvard Business School, Boston, MA, 02163, United States, kferreira@hbs.edu, Emily Mower

We develop a multi-product, attribute-based demand learning and dynamic pricing algorithm that efficiently learns customer demand to maximize revenue when a small number of price changes are allowed and when products may change over time. Our algorithm follows a learn-then-earn approach, using a novel adaptation of conjoint analysis in the learning phase. We validate the effectiveness of our algorithm through a three-month field experiment with an e-commerce company, where we change the price of products with daily assortment changes. Relative to a control group, our algorithm led to an 8.8% increase in average daily revenue.

2 - Markdown Optimization with Infinite Inventory

Su Jia, CMU Tepper, Pittsburgh, PA, 15232, United States, Andrew A. Li, Ramamoorthi Ravi

We study a single-product setting where the objective is to adaptively reduce the price over a finite sales horizon to maximize revenues. We assume that the expected revenue is unimodal over price so the challenge is to find the revenue maximizing price with an optimal combination of markdown exploration and exploitation. We show that a natural algorithm, which reduces the price at a suitable speed until it is confident that it has passed the optimal price, achieves near-optimal regret. Our tight regret bounds highlight the additional complexity of the markdown constraint in these price exploration problems and are asymptotically higher than corresponding bounds without this constraint.

3 - The Value of Personalized Pricing

Michael L. Hamilton, Columbia University, New York, NY, United States, mh3461@columbia.edu, Adam Elmachtoub, Vishal Gupta

Increased access to customer information has fueled interest in personalized pricing strategies, i.e., strategies that predict a customer's valuation for a product and then offer them a customized price. While the appeal of personalized pricing is clear, it may also incur costs in the form of market research, investment in information technology, and branding risks. In light of these tradeoffs, in this work, we study the value of personalized pricing over simpler pricing strategies and provide various closed-form upper and lower bounds on the ratio that depend on simple statistics and shape properties of the valuation distribution.

4 - Attribute-based Modeling of Product Recommendations

Sajad Modaresi, UNC Chapel Hill, Kenan-Flagler Business School, Chapel Hill, NC, 27514, United States, Sajad_Modaresi@kenan-flagler.unc.edu, Denis R. Saure, Fernando Bernstein

We study efficient real-time data collection approaches for an online retailer that dynamically personalizes assortments based on customers' attributes. We propose policies that leverage transaction data of customers with similar attributes to expedite the learning process and maximize revenue. We test the performance using a dataset from a Chilean retailer.

■ SB53

CC- Skagit 2

Innovations in E-commerce and Pricing

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Adam Elmachtoub, Columbia University, New York, NY, 10027, United States

1 - Incentivized Actions in Freemium Games

Lifei Sheng, University of Houston Clear Lake, Houston, TX, United States, sheng@uhcl.edu, Christopher Ryan, Mahesh Nagarajan

We study a common strategy of mobile game companies offering users "virtual" benefits to take actions in-game that earn the company revenue from third parties. Examples of "incentivized actions" include paying users in "gold coins" to watch video advertising. We explore the costs and benefits of offering incentivized actions as users progress in their engagement with the game. We find conditions for when it is optimal to follow a threshold policy of offering incentivized actions to low engaged users and then remove them once a user is sufficiently engaged. And we test such policy with real data. Finally, we provide insights into what types of games benefit most from offering incentivized actions.

2 - Loot Box Pricing and Design

Xiao Lei, Columbia University, New York, NY, 10027, United States, xl2625@columbia.edu, Ningyuan Chen, Adam Elmachtoub, Michael Hamilton

Online games garner annual revenues in the billions, more than half of which is from purchases of virtual items to be used by the player in the game. One popular way to sell in-game items are via loot boxes, which are random bundles of virtual items, the contents of which are revealed after purchase. We consider how to design loot boxes selling strategies, and compare them with bundle selling and separate selling. We show that in an asymptotic regime, carefully designed loot box strategies can garner as much revenue as bundle selling while inheriting many nice properties of separate selling. Our result and discussion give insights to customers, sellers and regulators.

3 - Optimal Pricing Policy for Service Systems with Reusable Resources and Strategic Customers

Yiwei Chen, University of Cincinnati, Cincinnati, OH, United States, Cong Shi

We consider a firm who uses a finite number of reusable resources to serve customers who are heterogeneous in their arrival times, service start and end times. The firm dynamically adjusts the service prices. Customers are forward-looking who strategize their times to request the services. We present a simple fixed price policy that the firm charges customers a flat rate of the resource usage per unit of time. We show that this policy is asymptotically optimal.

4 - Static Pricing: Universal Guarantees for Reusable Resources

Adam Elmachtoub, Columbia University, New York, NY, 10027, United States, Omar Besbes, Yunjie Sun

We consider a fundamental pricing model in which a fixed number of units of a reusable resource are used to serve customers. Our model represents various markets for reusable resources such as cloud computing, shared vehicles, rotable spare parts, and hotel rooms. We analyze this pricing problem when the firm attempts to maximize a weighted combination of three central metrics: profit, market share, and service level. While an optimal policy is fully dynamic, we prove that a static pricing policy simultaneously guarantees 78.9% of the profit, market share, and service level from the optimal policy. Notably this result holds for any service rate and number of units the firm operates.

■ SB54

CC- Skagit 3

Mechanisms and Market Equilibria

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Nicolas Stier-Moses, Facebook, Menlo Park, CA, 94025, United States

1 - Budget Management Strategies in Repeated Auctions

Anthony Kim, Columbia University, New York, NY, 10027, United States, aek2185@columbia.edu, Vahab Mirrokni, Santiago Balseiro, Mohammad Mahdian

One of the most important features advertising platforms often provide is budget management, which allows advertisers to control their cumulative expenditures. We study the "system equilibria" of a range of budget management strategies in terms of the seller's profit, buyers' utility and overall welfare. We show these methods admit a system equilibrium in a rather general asymmetric setting, analyze their stability properties, and prove dominance relations between them when buyers are symmetric. We also empirically compare the system equilibria of these strategies using real ad auction data.

2 - Competitive Equilibria and Trading Networks

Ozan Candogan, University of Chicago, Booth School of Business, Chicago, IL, 27708, United States, ozan.candogan@chicagobooth.edu, Markos Epitropou, Rakesh Vinay Vohra

Under full substitutability of preferences, we formulate the problem of finding a competitive equilibrium in trading networks as a generalized submodular flow problem. Our formulation enables us to perform comparative statics with respect to the number of buyers, sellers, and trades. For instance, we establish that if a new buyer is added to the economy, at an equilibrium the prices of all existing trades (including those that are not adjacent) increase. More generally, we identify certain "bridge" trades, whose addition to the network yields monotone changes in surpluses of downstream agents.

3 - Computing Large Market Equilibria Using Abstractions

Christian Kroer, Professor, Columbia University, Computer Science New York, NY, 15213, United States, christian.kroer@columbia.edu Christian Kroer, Professor, Facebook, New York, NY, United States, christian.kroer@columbia.edu, Alexander Peysakovich, Eric Sodomka, Nicolas Stier-Moses

Computing market equilibria is an important problem for market design. However, these equilibria require large amounts of information and computation. We consider ameliorating these issues by abstraction: an equilibrium is computed in a coarsened market, and then lifted to the original market. We show that several objectives have optimality bounds under this approach. We then study two practical abstraction methods: 1) filling in unknown valuations using matrix completion, 2) reducing the problem size by using representative buyers/items. We find that in real data allocations that are relatively close to equilibria can be computed from coarse abstractions.

4 - Tractable Equilibria in Sponsored Search with Endogenous Budgets

Dragos Florin Ciocan, INSEAD, Fontainebleau, France, Krishnamurthy Iyer

We consider an ad network's problem of allocating the auction for each individual impression to an optimal subset of advertisers, with the goal of revenue maximization. This is a variant of bipartite matching, except that advertisers may strategize by choosing their bidding profiles and their total budget. Under a linear budget cost of r, we show there exists an approximate equilibrium, where bidders bid their valuations shaded by a factor of 1+r, and set budgets slightly above their expected spending. Furthermore, in this approximate equilibrium, the optimal allocation for the ad network, as determined from an LP, is greedy with high probability.

■ SB55

CC- Skagit 4

Pricing and Revenue Management in Retail Operations

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Mehmet Sekip Altug, George Mason University, Washington, DC, 20052, United States

1 - The Equivalence of Restocking Fees and Rebates for Product Returns

Rachel Rong Chen, University of California-Davis, 3208 Gallagher Hall, One Shields Avenue, Davis, CA, 95616, United States, rachen@ucdavis.edu, Eitan Gerstner, Paolo Roma

Sellers experience excessive purchase cancellations in the form of product returns and seat cancellation of services such as hotels, cuisines and restaurants. Purchase cancellations result in lost sales, overproduction of goods and services, inflated shipping and handling costs, and damages to the environment. Are there policies that could help mitigate these damages? In this paper, we show that the restocking fee policy is equivalent to the rebate policy at reducing product returns.

2 - Endogenous Consumer Search under Asymmetric Product Familiarity

Michael Galbreth, University of Tennessee, Haslam College of Business, Knoxville, TN, 37996, United States, galbreth@utk.edu, Bikram Ghosh

When a consumer is familiar with one product but not its competitor, she is faced with a decision: buy what she knows, or engage in search to learn more. When search is costly, competing firms may attempt to encourage or discourage search by adjusting prices. We consider how these competitive dynamics are affected by marginal changes in the relative familiarity of competing products. An increase in familiarity for one product gives a firm pricing power, but it also gives its competitor a stronger incentive to decrease price to encourage search. We analytically investigate these opposing effects and discuss several directions for future research into competition under asymmetric product familiarity.

3 - Competitive Demand Learning and Pricing in Online Marketplaces

Arcan Nalca, Smith School of Business / Queen's University, Goodes Hall Queen's University, Kingston, ON, K7L 3N6, Canada, arcan.nalca@queensu.ca, Taner Bilgic, Mehmet Gumus

A pure online marketplace is an e-commerce site where independent sellers sell their products and transactions are managed by a marketplace platform. We focus on 3 characteristics of pure online marketplaces: 1) the demand-price relationship is unknown and has to be learned from sales data, 2) the platform observes sales transactions of all sellers while the sellers observe only their own sales, 3) platform allows sellers to exercise full control on their prices, and it only charges a commission to accumulate earnings for the platform. We evaluate alternative information sharing arrangements and contractual arrangements in platform-to-seller relationships in the presence of demand learning.

4 - Optimal Dynamic Allocation of Sales and Rental Inventory at a Retailer

Oben Ceryan, City, University of London, Cass Business School, London, EC1 Y. 8TZ, United Kingdom, Oben.Ceryan@city.ac.uk, Mehmet Sekip Altug

We consider a retailer that primarily rents and sells on the side over a given horizon. In every period, the retailer faces uncertain demand that splits between renters and buyers based on their utility. We characterize the optimal dynamic rental allocation policy and study its properties. We propose an implementable heuristic. We then extend our results to a retailer that primarily sells and rents on the side and study the duopoly case to characterize the emerging equilibrium. We derive the conditions that lead to "pure sales", "pure rental" and "mixed" equilibrium.

■ SB56

CC- Skagit 5

Theoretical Aspects of Pricing Mechanisms

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Manolis Pountourakis, University of Texas at Austin

1 - Optimal Auctions vs Anonymous Pricing

Emmanouil Pountourakis, UT Austin, Austin, TX, 78712, United States, Saeed Alaei, Jason Hartline, Rad Niazadeh, Yang Yuan

For selling a single item to agents with independent but non-identically distributed values, the revenue optimal auction is complex. With respect to it, Hartline and Roughgarden (2009) showed that the approximation factor of the second-price auction with an anonymous reserve is between two and four. We consider the more demanding problem of approximating the revenue of the ex ante relaxation of the auction problem by posting an anonymous price (while supplies last) and prove that their worst-case ratio is e. As a corollary, the upper-bound of anonymous pricing or anonymous reserves versus the optimal auction improves from four to e.

2 - Dynamic Procurement Auction

Ali Khodabakhsh, University of Texas at Austin, Austin, TX, 78703, United States, ali.kh@utexas.edu, Emmanouil Pountourakis, Evdokia Velinova Nikolova

In this talk we will talk about procurement auctions in a dynamic setting, in which the set of participating agents varies based on their previous assignments. This is motivated by electricity markets where the system operator wants to assign electricity generation to the available generators while satisfying the demand. In such a market, if a generator is not assigned frequent enough, they may not participate in the future rounds, which can increase the prices due to lack of competition.

3 - Sample Complexity for Non-truthful Mechanisms

Sam Taggart, Oberlin College, Oberlin, OH, United States, Jason Hartline

This paper considers the design of non-truthful mechanisms from samples. We identify a parameterized family of mechanisms with strategically simple winner-pays-bid, all-pay, and truthful payment formats. In general (not necessarily downward-closed) single-parameter feasibility environments we prove that the family has low representation and generalization error. Specifically, polynomially many bid samples suffice to identify and run a mechanism that is epsilon-close in Bayes-Nash equilibrium revenue or welfare to that of the optimal truthful mechanism.

4 - Returns on Privacy: Phase Transitions in Repeated Sales

Ezra Goss, Georgia Institute of Technology, Atlanta, GA, United States, ezragoss@gmail.com, Rachel Cummings, Yuan Cui, Samuel Taggart

We analyze a repeated pricing game between a buyer and seller in the presence of privacy and the absence of commitment power. Past work has shown that in the absence of privacy, equilibrium can fail to exist. Meanwhile, for full privacy, the standard results for single-shot games apply. We ask: what happens in the middle? We show that the results for extremely low and high levels of privacy are robust: equilibrium still does not exist with nominal but positive privacy, and full privacy can be significantly relaxed while preserving equilibrium. As a corollary, we obtain that the transition from nonexistence to the presence of equilibrium takes place at an intermediate level of privacy.

■ SB57

CC- Yakima 1

Humanitarian Analytics

Sponsored: Public Sector OR

Sponsored Session

Chair: Elisa Frances Long, UCLA Anderson School of Management, Los Angeles, CA, 90024, United States

1 - Hurricanes, Power Outages, and Utility Response

Elnaz Kabir, University of Michigan, Ann, MI, United States, Seth Guikema, Chengwei Zhai

Hurricanes cause substantial damage to power systems, leading to widespread, prolonged power outages. Utilities then have a significant logistical challenge to restore power across a large service territory under challenging conditions. Modeling is beginning to support this work in practice, with predictive models of the degree of damage and the duration of outages developed through research projects now being used in practice. This talk will giver an overview of this research and focus in particularly on how these models are transitioned from research to practice.

2 - Product Availability, Consumer Stockpiling, and Hurricane Events

Xiaodan Pan, Concordia University, Montreal, QC, H3H 0A1, Canada, xiaodan.pan@concordia.ca, Martin E. Dresner, Benny Mantin, Jun Zhang

The provision of essential supplies is a key service provided by retailers when demand spikes due to consumer stockpiling during environmental emergencies. We study consumer stockpiling behavior prior to the onset of hurricane landfalls, with a focus on the impact of this behavior on in-store product availability for various formats of retail store outlets. Our study points to the need for retailers to carefully monitor factors affecting consumer stockpiling behavior during the hurricane season that will allow them to better preposition inventories and fulfill consumer demand.

3 - Tracking Misinformation on Social Media: a Machine Learning Approach

Kyle J. Hunt, Student and Research Assistant, University at Buffalo, Buffalo, NY, 14221, United States, kylehunt@buffalo.edu, Puneet Agarwal, Jun Zhuang

A prodigious gap in research exists in studying the tracking of misinformation on social media platforms in times of disasters and other crisis events. Such studies would offer organizations and agencies new tools and ideologies to track identified misinformation on platforms such as Twitter and make informed decisions on whether or not to use their resources in order to debunk the false information. In this work, we fill the research gap by training eight different machine learning algorithms to predict the veracity of misinformation-related tweets that are spread during crisis events. The tweets are tracked in real-time based on the veracity of their content as either true, false, or neutral.

4 - Political Storms: Tracking Hurricane Evacuation Behavior using Smartphone Data

Elisa Long, UCLA Anderson School of Management, 110 Westwood Plaza, Gold Hall B-508, Los Angeles, CA, 90024, United States, elisa.long@anderson.ucla.edu, Keith Chen, Ryne Rohla

The 2017 hurricane season devastated the U.S. gulf coastline but, despite extensive warnings, most residents did not evacuate before the storms hit. Using a GPS dataset for 2.7 million smartphone users in Florida and Texas, along with census and precinct voting data, we empirically examine demographic predictors of hurricane evacuations. A strong predictor was the 2016 Democrat/Republican President vote share, but only after conservative media skepticism of hurricane warnings emerged in 2017. Using spatial regression discontinuity, we confirm the causal impact of hurricane alerts by comparing evacuation rates for residents on opposite sides of county boundaries receiving different alerts.

■ SB58

CC- Yakima 2

Joint Session Policy/HAS: Pricing Models in Pharmaceutical and Healthcare Markets

Emerging Topic: Policy & Government

Emerging Topic Session

Chair: Turgay Ayer, Georgia Institute of Technology, Atlanta, GA, 30332, United States

Co-Chair: Zhaowei She, Georgia Institute of Technology, Atlanta, GA, 30067, United States

1 - Outcome-based Reimbursement: The Solution to High Drug Spending?

Liang Xu, Pennsylvania State University, State College, PA, 16801, United States, lzx103@psu.edu, Hui Zhao, Hongmin Li

To induce insurer coverage of expensive new drugs, manufacturers have proposed the outcome-based reimbursement (OBR) scheme, under which the insurer will receive a rebate if the realized drug effectiveness does not reach the expected level. We investigate the impact of OBR on the insurer, manufacturer and patients, by developing a Stackelberg game framework to capture the optimal design of the OBR scheme. We apply data on 15 drugs treating hyperlipidemia, a common disease, and provide calibrated answers to the above questions for these drugs. Our results show that, while OBR reduces insurer's risk, it does not lower insurer's spending due to the manufacturer's inflated price.

2 - Outcomes-based vs. Traditional Pharmaceutical Contracts

Andrew ElHabr, Georgia Institute of Technology, Atlanta, GA, United States, andrewelhabr@gatech.edu, Can Zhang, Turgay Ayer

We study under what market conditions and drug characteristics payers and pharmaceutical manufacturers are better off engaging in an outcomes-based contract, an agreement that links payments for drugs to drug effectiveness, over a traditional contract. Our findings include that moderately cheap and effective drugs can be good candidates for outcomes-based contracts. We also find that an agreement on preferred drug formulary placement in exchange for lower per-unit drug price can be beneficial to all stakeholders.

3 - Financing Hepatitis C Treatment Through the Netflix Model

Zhaowei She, Georgia Institute of Technology, Atlanta, GA, 30067, United States, zhaowei@gatech.edu, Yueran Zhuo, Jagpreet Chhatwal, Turgay Ayer

Several state governments (e.g. Louisiana and Washington) recently entered into Netflix-Style contracts with their pharmaceutical partners (e.g. Gilead and AbbVie), where the state agency makes a fixed lump sum payment to its pharmaceutical partner in exchange for unlimited access of Hepatitis C drugs for its Medicaid patients. We analyze these emerging Netflix-Style payment models for pharmaceutical treatments from a mechanism design perspective, and characterize conditions under which these contracts would improve the efficiency of pharmaceutical market.

4 - A Study of Prospectively-paid, Performance-based Incentive Payments in Healthcare

Zheng Han, University of Kansas, Lawrence, KS, 66045, United States, Mazhar Arikan, Suman Mallik

We study decision problems of a healthcare practice under Comprehensive Primary Care Plus (CPC+) payment scheme, which aims to strengthen primary care by providing practices additional financial resources and flexibility to make investments and improve quality of care. We develop insights on the resulting quality of care, using fee-for-service (FFS) payment scheme as a benchmark.

■ SB58a

CC- Chelan 1

11:00-11:45 The AnyLogic Company / 11:45-12:30 Palisade

Vendor Tutorial

1 - Simulation Models as Virtual Environments to Train and Test AI for Business Applications

Arash Mahdavi, Anylogic Company, Chicago, IL, United States

In this tutorial, we will discuss how you can leverage unique features of AnyLogic simulation software and AnyLogic Cloud to solve your business challenges or perform scientific research. We demonstrate application of simulation in various domains and demonstrate state-of-the-art technologies that can take your simulation models to the next level in terms of sophistication and usefulness.

2 - Quantitative Risk Analysis in Excel with @RISK

José Raúl Castro, Palisade Trainer/Consultant, Palisade Corporation, Ithica, NY, United States

This tutorial will guide you in the use of @RISK for analyzing historical data and making better decisions in an uncertain business environment. @RISK is part of Palisade's Decision Tools Suite and runs as an add-in for MS Excel. It provides all the features you need to quantify and understand risks with the support of Monte Carlo Simulation, including graphical capabilities and quick reports to help you present results to a non-technical audience.

■ SB59

CC- Chelan 2

Big Data Science: Classical Origins and New Frontiers

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Ran Jin, Virginia Tech, Blacksburg, VA, 24061, United States

Co-Chair: Lulu Kang, Illinois Institute of Technology, Chicago, IL, 60616, United States

1 - Information Quality, the New Challenge in the Data Science Age

Ron Kenett, KPA, Israel, ron@kpa-group.com

The quality of information generated in data-driven analytics is of central importance in modern data science. The talk will present a framework for evaluating, analyzing, and improving the quality of information called InfoQ. InfoQ consists of four components (goal, data, analysis and utility) and eight dimensions. The talk will also present recent initiatives to define data readiness level (DRL) as a basis for generating InfoQ.

2 - Data Science and Informs

Yu Ding, Texas A&M University, Dept. Industrial & Systems Engineering, College Station, TX, 77843-3131, United States, yuding@tamu.edu

During 2018's NSF Big Data PI meeting, Dr. Michael Franklin gave a keynote speech talking about what data science is and whether data science is a new discipline. This speaker wants to continue this conversation but with more focus on data science's interaction and relevance to INFORMS communities

3 - Statistical Process Control in the Big Data Era

Peihua Qiu, University of Florida, Gainesville, FL, 32610, United States, pqiu@ufl.edu

"Big data" is a buzzword these days due to an enormous amount of data-rich applications in different industries and research projects. In practice, big data often take the form of data streams in the sense that new batches of data keep coming over time. One fundamental research problem for analyzing such big data streams in a given application is to sequentially monitor the underlying process behind the observed data to see whether it is longitudinally stable, or how its distribution changes over time. To monitor a sequential process, one major statistical tool is the statistical process control (SPC), which has been used mainly for monitoring production lines in manufacturing industries during the past several decades. With many new and versatile methods developed in recent SPC research, SPC can provide a powerful tool for handling many other applications. In this talk, I will introduce some traditional and more recent SPC concepts and methods, and discuss some challenges in the interface of the existing SPC methods and some big data applications as well.

4 - Big Data Origins and New Frontiers

Lulu Kang, Illinois Institute of Technology, 10 West 32nd Street, Chicago, IL, 60616, United States, lkang2@iit.edu

Under the big data paradigm, the application and study of data science are crucial to many sciences, engineering, and business disciplines. We invite three prominent scholars to present their discoveries, knowledge, and experiences in the field of data science. Dr. Ron S. Kennett will present a framework for evaluating, analyzing, and improving the quality of information. Dr. Yu Ding will give a talk on data science's interaction and relevance to INFORMS communities. Dr. Peihua Qiu will introduce some traditional and more recent Statistical Process Control concepts and methods and discuss some challenges in the interface of the existing SPC methods and some big data applications as well.

■ SB59a

CC- Chelan 3

Disaster and Emergency Management II

Contributed Session

Chair: Alireza Inanlouganji, Arizona State University, Tempe, AZ, 85282, United States

1 - Drone Aided Road Recovery and Relief Operation in Disasters

Mohammad Amin Farzaneh, Florida International University, Miami, FL, United States, mfarz004@fiu.edu, Shabnam Rezapour

Recovery of primary roads accelerates relief distribution in disasters. In this paper, three interconnected models are proposed for damage assessment and road recovery in a way that maximizes the speed of relief distribution to reach out the disaster affected areas as soon as possible and consequently save more people. The first model is about the drone aided damage assessment, the second one is about the road recovery process and the third one is for relief operations. models are tested for a road network on the southeast coast of the US and the results are compared with benchmarks.

2 - A Hierarchical Decision-making Framework for the Efficient Disaster Management Strategy

Seunghan Lee, University of Arizona, Tucson, AZ, United States, shlee17@email.arizona.edu, Saurabh Jain, Young-Jun Son

The importance of improvising effective disaster management policies has increased over the past decade. However, due to the increasing effects of social networks and the diversity of individual opinions, predicting people's behaviors during the disaster becomes challenging. Thus, we propose a generalized decision-making framework to represent realistic human behavior in a disaster situation. The framework assists us in examining the interaction effects within the social network, which will help to analyze innovation diffusion and opinion formation processes. We also demonstrate the necessary conditions for the best policy for maximizing the level of disaster preparedness and responses.

3 - Empirical Study: Noncompetitive Contracts and Public Assistance Alternative Programs in Post-disaster Recovery

Andriy Shapoval, Georgia Tech, Atlanta, GA, United States

This work considers use of Public Assistance from U.S. Federal Emergency Management Agency (FEMA). Alternative procedures are still called pilot programs and subject to updates and changes. Features of large-scaled recovery projects are analyzed together with situations of noncompetitive contracts.

4 - Simulation Based Rollout Algorithm for Disaster Response in Large Power Networks

Alireza Inanlouganji, Arizona State University, Tempe, AZ, United States, ainanlou@asu.edu, Giulia Pedrielli

This work investigates the problem of real-time recovery of power networks under iteratively updated natural disaster information, where the stochastic model of the effect of weather conditions over the state of the power network is known. We formulate the problem as a Stochastic Dynamic Program, and deal with the curse of dimensionality by developing a novel Rollout algorithm that uses a local optimization as base heuristic. The reward is estimated using a simulator for the network. We evaluate the performance of the algorithm in terms of both solution accuracy and computational time.

■ SB60

CC- Chelan 4

IISE Transactions Invited Session

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Judy Jin, University of Michigan, Ann Arbor, MI, 48109-2117, United States

1 - A Prediction and Compensation Scheme for In-plane Shape Deviation of Additive Manufacturing with Information on Process Parameters

Andi Wang, Georgia Institute of Technology, Atlanta, GA, United States, andi.wang@gatech.edu, Longwei Cheng, Fugee Tsung

Shape fidelity is a critical issue that hinders the wider application of Additive Manufacturing (AM) technologies. In this article, we aim to improve the shape fidelity of AM products through compensation, with the information on the process parameters. To achieve this, a two-step scheme is proposed to predict the in-plane deviation of the product shape, which relates to the process parameters and the two-dimensional input shape. Based on this prediction procedure, a shape compensation strategy is developed that greatly improves the dimensional accuracy of products. Experimental studies of fused deposition modeling processes validate the effectiveness of our proposed scheme.

2 - Monitoring Serially Dependent Categorical Processes with Ordinal Information

Jian Li, Xi'an Jiaotong University, Xi'an, China, jianli@xjtu.edu.cn, Jiakun Xu, Qiang Zhou

There is usually natural order among the attribute levels of categorical variables. We consider monitoring a serially dependent ordinal categorical process, which is driven by a latent autocorrelated continuous process. The unobservable values of the continuous variable determine the levels of the ordinal variable. We transform the data into a multi-way contingency table and describe them with our proposed novel ordinal log-linear model. This model can incorporate both the marginal distribution of attribute levels and the serial dependence. A chart is finally proposed to monitor if there is shift in the location parameter or in the autocorrelation coefficient of the latent continuous variable.

3 - Identifying Nonlinear Variation Patterns with Deep Autoencoders

Phillip Howard, Intel Corporation, Chandler, AZ, United States, Daniel Apley, George Runger

The discovery of nonlinear variation patterns in high-dimensional profile data is an important task in quality control and manufacturing. We present an automated method for discovering nonlinear variation patterns using deep autoencoders. The approach provides a functional mapping from a low-dimensional representation to the original spatially-dense feature space of the profile data that is interpretable and efficient. We compare our approach to other methods for discovering variation patterns in profile data. Our results indicate that deep autoencoders outperform alternative approaches in reproducing the original profiles from the learned variation sources.

4 - Layer-wise Spatial Modeling of Porosity in Additive Manufacturing

Jia (Peter) Liu, Virginia Tech, Blacksburg, VA, United States, Chenang Liu, Yun Bai, Prahalad Rao, Chris Williams, Zhenyu (James) Kong

In additive manufacturing (AM), porosity has a direct impact on the part functional integrity. To quantify the underlying mechanism of porosity formation and evolution in an AM part, an augmented layer-wise spatial log Gaussian Cox process (ALS-LGCP) model is developed by leveraging the spatiotemporal correlation among pores on the sequential X-Ray CT scans. ALS-LGCP unveils the structure of pore formation and predicts when and where the pores progress on future layers. This research marks a critical step towards a model-based understanding of defect formation in additive manufacturing and has promising potential to be applied in online, in-situ X-Ray-based monitoring of AM processes.

■ SB61

CC- Chelan 5

Online Monitoring and Anomaly Detection in Spatio-temporal Data

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Hao Yan, Tempe, AZ, 85281, United States

1 - Rapid Detection of Hot-spot by Tensor

Yujie Zhao, Georgia Institute of Technology, Atlanta, GA, United States, yzhao471@gatech.edu

In bio-surveillance and healthcare applications, it is possible that data has circular patterns. One monitors multiple data sources from spatial locations over time and is interested in detecting hot-spots from some data sources and some sparse spatial locations that are persistent outliers over time. We propose a tensor decomposition method to detect which, where, when the hot-spots occur. Our proposed methods represent the observed raw data as three-dimensional tensor and decompose it into three components: smooth global trend, local hot-spot, and residuals. A combination of lasso and fused lasso is used to estimate parameters with regularization term for continuity and circularity.

2 - Spike Slab Based Partial Observable Online Monitoring with Thompson Sampling

Chen Zhang, Tsinghua University, e1-07-26, 3 Engineering Drive, Singapore, 117576, Singapore, zhangchen01@tsinghua.edu.cn

We consider online multivariate process change detection when only partial observations can be achieved for each sampling point. In particular, we pre-define some interested anomaly patterns, and test whether the online data have significant projections on these patterns via spike slab variational inference in the Bayesian framework. We also design an adaptive sampling framework to decide which dimensions to observe for the next sampling point based on Thompson sampling algorithm.

3 - High-dimensional Anomaly Detection with Adversarial Autoencoders

Nurettin Dorukhan Sergin, Arizona State University, Tempe, AZ, United States, nsergin@asu.edu, Hao Yan, Huai-ming Yeh

Nonlinear profile and image-based process monitoring and diagnosis have recently attracted increasing attention among researchers as well as practitioners. Yet, existing profile monitoring techniques based on linear models such as PCA fail to represent the complex spatial in-control pattern. Inspired by the recent development and success of deep learning techniques, we propose to combine deep generative models with process monitoring techniques. Our findings suggest that a regularized deep generative model can work well with small amounts of in-control data. We demonstrate in-depth results both in simulated profile datasets and a real-life case of a steel manufacturing process imagery.

■ SB62

CC- Tahoma 1

Lightning Round: HAS Doctoral Students and Post-docs on the Job Market

Sponsored: Health Applications

Sponsored Session

Chair: Anahita Khojandi, University of Tennessee, Knoxville, TN, 37996, United States

Co-Chair: Hadi El-Amine, George Mason University, Fairfax, VA, 22030, United States

1 - Moderator

Anahita Khojandi, University of Tennessee, 521 Tickle Building, Knoxville, TN, 37996, United States

The purpose of this session is to bring visibility to the students and postdocs looking for academic positions with a focus on health applications and/or theory, and facilitate recruitment for departments interested in growing their capabilities in healthcare-related research/teaching. The participants in the session each will have up to 4 minutes to present 1-2 slides about their research interests and past projects. After the presentations are over, the audience and participants will have time to mingle and have one-on-one interactions.

Panelists

- Ai Ren, University of Maryland-College Park, Robert H. Smith School of Business, College Park, MD, 20740, United States
- Carolina Vivas-Valencia, Purdue University, West Lafayette, IN, 47906, United States
- Esmaeil Keyvanshokooh, University of Michigan-Ann Arbor, Ann Arbor, MI, 48108-1020, United States
- Gian-Gabriel P. Garcia, University of Michigan, Ann Arbor, MI, 48105, United States
- Justin Kistler, University of South Carolina, Columbia, SC, 29212, United States
- Karen T. Hicklin, University of North Carolina at Chapel Hill, Chapel Hill, NC, 27599-7411, United States
- Lina Song, Harvard University, Cambridge, MA, 02138, United States
- Masoud Kamalahmadi, Indiana University, Bloomington, IN, 47405, United States, maskamal@iu.edu
- Sina Ansari, Tuck School of Business Dartmouth College, Hanover, NH, 03755, United States
- Temitayo Ajayi, Rice University, Houston, TX, 77004, United States
- Toyya Pujol-Mitchell, Georgia Institute of Technology, Atlanta, GA, 30363, United States
- Yueran Zhuo, Harvard University, Cambridge, MA, 02128, United States

■ SB63

CC- Tahoma 2

OR Applications in Cancer Care

Sponsored: Health Applications

Sponsored Session

Chair: Iakovos Toumazis, Stanford University, Stanford, CA, 94305-5446, United States

1 - Benefits and Harms of Mammography Screening for Women with Down Syndrome

Oguzhan Alagoz, University of Wisconsin-Madison, 3242 Mechanical Engineering Building, Madison, WI, 53706, United States, alagoz@engr.wisc.edu, Ali Hajjar, Sarocha Chootipongchaivat, Nicolien van Ravesteyn, Jennifer Yeh, Mehmet Ergun, Harry de Koning, Brian Chicoine, Barry Martin

Women with Down syndrome have lower life expectancies and risk of breast cancer compared to women without Down syndrome. We used two established Cancer Intervention and Surveillance Modeling Network (CISNET) simulation models that were used to inform national breast cancer screening guideline development to estimate the benefits, harms, and commonly used harm/benefit ratios of various mammography screening strategies for women with Down syndrome. The harm/benefit ratios for various mammography screening strategies in women with Down syndrome are not as favorable as those for average-risk women.

2 - Search and Sensitivity in the Creation of Natural History Models to Support Cancer Care

Michael J. Hintlian, University of Southern California, Los Angeles, CA, 90006, United States, Julia L. Higle

Model-based analysis that supports medical decision-making relies on disease models. Model parameter values are typically identified via a search process during calibration. Common search techniques include random sampling, Nelder-Mead, and simulated annealing. Search methods can have a significant impact on the parameters identified, as well as the results of subsequent analyses. We introduce search methods that expand on existing techniques and are designed to find models quickly while maintaining desirable properties. We demonstrate these methods on disease models at scale.

3 - Optimizing the Use of Supplemental Breast Screening Ultrasound and MRI

Burhaneddin Sandikci, University of Chicago, Booth School of Business, Chicago, IL, 60637, United States, burhan@chicagobooth.edu, Mucahit Cevik, David Schacht

Timely detection of breast cancer is hindered by the imperfect nature of the tests used. In the U.S. , the gold standard mammography screening is increasingly supplemented with ultrasound and MRI screening tests, particularly for high-risk women including those with dense breasts. Breast density not only impairs screening accuracy, but also significantly increases risk of developing breast cancer. We formulate a personalized dynamic optimization model tracking significant attributes of a women (e.g., her age and breast density) to optimize the use of supplemental tests and compare its results to mass screening guidelines to help quantify the value of supplemental screening.

4 - Improving the Efficiency of Patient-Centered Medical Decision Making for Preventive Screening

M. Gabriela Sava, Assistant Professor, Clemson University, College of Business, Clemson, SC, 29634, United States, msava@clemson.edu, Luis G. Vargas, Jerrold H. May, James G. Dolan

Sensitivity and stability analyses are important when employing a multi-criteria model for medical decision making. But the cost of gathering the data for those analyses may only be less than the benefit for atypical patients. For routine cases, it may be more efficient to maintain a library of archetypical analyses, and to select one based on easily obtained measures. We discuss that conjecture in the context of colorectal cancer screening, using data from a substantial set of real patients.

5 - Optimizing the Net-Benefit of Lung Cancer Screening Using a Partially Observable Markov Decision Process

Iakovos Toumazis, Stanford University, Department of Radiology, Stanford, CA, 94305-5446, United States, iakovost@stanford.edu, Oguzhan Alagoz, Ann Leung, Sylvia Plevritis

Current recommendations on lung cancer (LC) screening define eligibility based on age, smoking intensity and years since smoking cessation. Many other risk factors associated with LC incidence, along with the cost of screening are not taken into consideration leading to sub-optimal strategies from a cost-effectiveness point of view. We propose a partially observable Markov decision process (POMDP) that maximizes the net-benefit of a LC screening program. We develop a screening framework that offers individualized optimal cost-effective screening decisions based on the risk of ever-smoked individuals while accounting for past screening results and changes in individuals' smoking behavior.

■ SB64

CC- Tahoma 3

Global Health Operations

Sponsored: Health Applications

Sponsored Session

Chair: Jonas Oddur Jonasson, MIT Sloan School of Management, Cambridge, MA, 02142, United States

1 - Machine Learning Based Risk Stratification for Early Detection of Diabetes and Hypertension in Resource-limited Settings

Justin J. Boutilier, University of Wisconsin-Madison, Madison, WI, United States, Timothy Chan, Manish Ranjan, Sarang Deo

The impending scale up of non-communicable disease screening programs coupled with limited health resources require that such programs are as efficient as possible. We demonstrate that machine learning risk stratification algorithms that are tailored for community-based screening programs in low-resource settings could save approximately $1.19 billion USD for diabetes and $960 million USD for hypertension by reducing missed diagnoses.

2 - Vaccine Distribution Chains in Low- and Middle-income Countries: The Case of Madagascar

Kim De Boeck, KU Leuven, Leuven, Belgium, kim.deboeck@kuleuven.be, Catherine Jenny Decouttere, Nico Vandaele

Access to immunization varies greatly across the world. In order to increase vaccine coverage, the required vaccines need to be able to reach the targeted population. However, in low- and middle-income countries, this often turns out to be a challenging task. We give an introduction to the case of Madagascar where the vaccine distribution chain is heavily impacted by the rainy season.

3 - Shared Medical Appointments – An Innovative Approach to Healthcare Delivery

Nazli Sonmez, London Business School, London, United Kingdom, nsonmez@london.edu, Kamalini Ramdas, Ryan Buell

We examine shared medical appointments (SMAs) as a substitute for regular one-on-one appointments. Under this innovative approach, a group of patients with similar chronic conditions meet with a doctor simultaneously and receive one-on-one care. We conduct a randomized controlled trial at the Aravind Eye Hospital, in Pondicherry, India to assess the effectiveness of shared medical appointments versus traditional one-on-one appointments for glaucoma. Preliminary results obtained with the data suggest that the knowledge and satisfaction level of patients who attend shared medical appointments is significantly higher than that of patients who attend one-on-one appointments.

4 - Operational Challenges in a Medical Transportation Platform in India

Gonzalo Romero, Rotman, University of Toronto, Toronto, ON, M4K 3H6, Canada, gonzalo.romero@rotman.utoronto.ca, Andre Du Pin Calmon, Luk N. Van Wassenhove

We model and analyze the operational challenges faced by a medical transportation platform in India. In many developing countries, there is no centralized ambulance dispatcher. Therefore, patients must call their local hospital or hire a private ambulance, resulting in long waiting times for patients and costly routes for ambulances.

5 - Perspective on (Research) Problems in Global Health Delivery

Ravi Anupindi, University of Michigan, Ann Arbor, MI, 48109, United States

In this talk I will share some my experiences / understanding of problems in global health delivery based on field projects / case studies in Africa and India. Through this lens I will try to reflect on the current state and future opportunities research in this space.

■ SB65

CC- Tahoma 4

HAS Distinguished Speakers – I

Sponsored: Health Applications

Sponsored Session

Chair: Mark P. Van Oyen, University of Michigan, Ann Arbor, MI, 48109-2117, United States

Co-Chair: Hui Zhao, The Pennsylvania State University, Smeal College of Business, University Park, PA, 16802, United States

1 - Personalized Medicine: A Vision for Research and Education

Dimitris Bertsimas, Massachusetts Institute of Technology, Cambridge, MA, 02139, United States

Medicine as taught in medical schools and as practiced today is not personalized. We present a research program to develop an algorithmic theory of personalized medicine applied to the major human diseases. Using electronic medical records, and genomic data and in collaboration with major medical centers and medical doctors, we present our ongoing efforts to develop algorithms that propose personalized treatments for individual patients that suffer from these diseases. The new personalized medicine algorithms are based on optimal classification, regression and prescription trees developed in Bertsimas and Dunn (2017,2019), machine learning methods that combine interpretability and state of the art performance We report on our work on cardiovascular disease, stroke, cancer, surgery, diabetes, blood pressure and liver transplantation and their impact in medical practice. We further discuss the implications of our work on the education of the next generation of doctors and analytics students.

2 - Health Care Collaboration: A Case Study

Martin L. Puterman, Professor Emeritus, University of British Columbia, Sauder School of Business, Vancouver, BC, V6T 1Z2, Canada, martin.puterman@sauder.ubc.ca

In this talk I will describe my lengthy collaboration with the British Columbia Cancer Agency. I will discuss how the collaboration came about, the research produced, the impact on practice and the training that has taken place. I will also explore (with the assistance of Leah Weber) the challenges of developing software in a health system environment. Throughout the talk, I will highlight both methodological and practical challenges and how they were overcome.

■ SB66

CC- Tahoma 5

Disease Modeling to Inform Health Policy

Sponsored: Health Applications

Sponsored Session

Chair: Anneke Claypool, Stanford University, Stanford, CA, 94305, United States

1 - Quantifying Positive Health Externalities of Disease Control Interventions: Modeling Chikungunya and Dengue

Anneke Claypool, Stanford University, Stanford, CA, 94305, United States, Margaret L. Brandeau, Jeremy Goldhaber-Fiebert

Health interventions can generate positive externalities not captured in traditional, single-disease cost-effectiveness analyses (CEAs), potentially biasing results. For example, when a mosquito species can transmit multiple diseases, a single-disease CEA comparing disease-specific interventions (e.g., vaccination) with interventions targeting the mosquito population (e.g., insecticide) would underestimate insecticide's benefits. We develop three dynamic transmission models: chikungunya, dengue, and combined chikungunya and dengue. We compare the models' predictions of cost-effectiveness of an insecticide, a chikungunya vaccine, and an insecticide plus vaccine campaign.

2 - An Agent-based Algorithm for Studying the Dynamics of Transmission Clusters for HIV

Sonza Singh, University of Massachusetts-Amherst, Amherst, MA, 01003, United States, sonzasingh@umass.edu, Anne Marie France, Yao-Hsuan Chen, Zihao Li, Paul Farnham, Stephanie Sansom, Alexandra Oster, Chaitra Gopalappa

We test the capacity of an evolving contact network algorithm to generate HIV transmission clusters of different sizes in a hypothetical population, and we examine the sensitivity of behavioral and care parameters on the cluster properties. Identifying a methodology to generate the dynamics related to transmission clusters can help develop a simulation model for HIV transmissions in the US and inform intervention strategies.

3 - When and What to Test for: A Cost-effectiveness Analysis of Test-and-treat Strategies for Undifferentiated Febrile Illness in the Era of Responsible Antibiotic Use

Zhenhuan Zhang, PhD Candidate, University of Minnesota, Minneapolis, MN, 55414, United States, Diana Maria Negoescu, Claudia Munoz-Zanzi

Febrile illness caused by viral and bacterial infectious diseases often have similar symptoms and are difficult to differentiate without diagnostic tests. If not treated appropriately, patients may experience serious complications. The question of what diagnostic tests to use to inform the timing of antibiotic therapy remains an open problem for health services facing limited resources. We constructed Markov models to capture febrile illness progression and formulated the problem of minimizing the weighted average of antibiotic underuse and overuse to inform optimal test-and-treat strategies in two settings in Thailand with contrasting bacterial versus viral disease prevalence.

4 - Resource Allocation for Hepatitis C Elimination

Qiushi Chen, Assistant Professor, Pennsylvania State University, University Park, PA, 16802, United States, Turgay Ayer, Jagpreet Chhatwal

More than 70 million people are chronically infected with hepatitis C virus (HCV) globally. With the recent availability of new treatments, the World Health Organization (WHO) set an ambitious target to eliminate HCV by 2030. However, high treatment cost and unawareness of infection remain major barriers to elimination. In this study, we develop an HCV transmission model that aids in optimal allocation of resources to scale-up HCV screening and treatment that can lead to HCV elimination. We present optimal allocation policies in different health care settings and target population profiles.

5 - Performance Assessment Methods for U.S. Organ Donation Rates

Luke DeRoos, University of Michigan, Ann Arbor, MI, 48104, United States, lkbruski@umich.edu, Wesley Marrero, Mariel Sofia Lavieri, David W. Hutton, Neehar Parikh

Organ transplantation is a life-saving and cost-effective treatment for patients with end-organ failure. However, the current supply of donors is unable to match demand, resulting in increased mortality of waitlisted patients. To understand the performance of different organ procurement organizations (OPOs), we analyze temporal and spatial trends in U.S. organ donation for different demographics. We compare potential OPO grading systems using rank correlation techniques and discuss the impact of performance assessment on transplantation policy.

■ SB67

S- Virginia

Nicholson Student Paper Competition I

Emerging Topic: Nicholson Student Paper Competition

Emerging Topic Session

Chair: Lewis Ntaimo, Texas A&M University

Co-Chair: Shipra Agrawal, Columbia University

1 - Beating the Curse of Dimensionality in Optimal Stopping

Yilun Chen, Cornell, Ithaca, NY, 14853, United States

Please check the mobile app or onlinefor this abstract

2 - Learning Graphs from Noisy Epidemic Cascades

Jessica Hoffmann, University of Texas at Austin, Austin, TX, United States

Please check the mobile app or online for this abstract

3 - Hedging the Drift: Learning to Optimize under Non-Stationarity

Ruihao Zhu, Massachusetts Institute of Technology, Cambridge, MA, 02139, United States

Please check the mobile app or online for this abstract

4 - Dynamically Protecting Privacy, under Uncertainty

Mine Su Erturk, Stanford University, Stanford, CA, 94305, United States

Please check the mobile app or online for this abstract

5 - Large Dimensional Latent Factor Modeling with Missing Observations and Applications to Causal Inference

Ruoxuan Xiong, Stanford University, Stanford, CA, 94305, United States

Please check the mobile app or online for this abstract

■ SB68

S- University

Location Models for Healthcare Access

Sponsored: Location Analysis

Sponsored Session

Chair: Kayse Lee Maass, Northeastern University, Boston, MA, 02115, United States

1 - Designing a Dynamic Network of Dialysis Facilities

Michael G. Klein, San Jose State University, San Jose, CA, 95192-0069, United States, michael.klein@sjsu.edu

Kidney failure is treated with dialysis until transplant or death. Regardless of the travel burden, many patients always opt to go to a facility, while some always opt for home dialysis. For others, the choice varies depending on the location of available facilities. Existing patients also switch dialysis modes (e.g. from facility-based dialysis to home dialysis) bringing different requirements for providers over time. I propose a new model to determine the best network of dialysis facilities from an access to care perspective. Through a California case study, I propose to illustrate the model and help identify areas for improvement.

2 - Optimizing Deployment of Mobile Screening Team to Eradicate HAT

Joris Van de Klundert, Professor, Vice Dean, Mohammad bin Salman College, Saudi Arabia, jklundert@mbsc.edu.sa, Harwin de Vries, Albert P. M. Wagelmans

Deceased donor kidney waiting time inequities among patients of various blood types and races are persistent despite reduction efforts. In the USA, the wait list continues to increase above 100.000 patients, with considerable variation in waiting time and survival rate. We consider queuing models with patient and deceased donor kidney arrivals and analyse system performance for blodd types and races. We present necessary and sufficient conditions for equitable waiting time (growth) across blood types and races for unstable and for stable systems, using a novel network flow formulation. It enables to maximize various forms of equity, for which we present results using UNOS data for the USA.

3 - Optimal Defibrillator Deployment Versus Actual Deployment

Timothy Chan, University of Toronto, Mechanical and Industrial Engineering, Toronto, ON, M5S 3G8, Canada, Christopher Sun

Public defibrillators, which are located throughout cities worldwide, can resuscitate cardiac arrest victims by bystanders with no training. However, location decisions to date are not data-driven. In this talk, we present a head-to-head comparison of optimal defibrillator locations against actual defibrillator locations using nine years of real data. At every decision epoch, the optimization model can only make decisions based on past data. On out-of-sample, future cardiac arrests, the optimization model improves spatiotemporal coverage by 50-100% compared to actual location decisions, translating to significant increases in estimated bystander resuscitation and survival.

4 - Using Simulation to Evaluate Scheduling Policies for Specialty Care to Consider Patient Preferences

Adam VanDeusen, Doctoral Candidate, University of Michigan, Ann Arbor, MI, 48109, United States, ajvandeu@umich.edu, Sameer Saini, Megan Adams, Jacob Kurlander, Amy Cohn

Healthcare appointments can now be conducted in many modalities, including face-to-face, phone, or video visits. Patients have preferences about how they receive healthcare; these preferences are often related to geographic distance to care. We present a case study for considering such preferences in patients with gastroesophageal reflux disease using simulation. In this study, we model different scheduling policies to evaluate how accommodating patient preferences impacts patient access. We hope such models can improve access to specialty care, especially for patients who would travel long distances to receive care.

■ SB69

S- Seneca

Navigating the Review Process - Recently Accepted Papers in Analytical Healthcare OM

Sponsored: Manufacturing & Service Oper. Mgmt/Healthcare Operations

Sponsored Session

Chair: Elodie Adida, University of California-Riverside, Riverside, CA, 92521, United States

Co-Chair: Fernanda Bravo, UCLA Anderson School of Management, Los Angeles, CA, 90024, United States

1 - Prioritizing Hepatitis C Treatment in U.S. Prisons

Can Zhang, Duke University, Durham, NC, 27708, United States, Turgay Ayer, Anthony Bonifonte, Anne Spaulding, Jagpreet Chhatwal

HCV prevalence in prison systems is ten times higher than the general population, and hence prison systems offer a unique opportunity to control the HCV epidemic. New HCV treatment drugs are very effective, but providing treatment to all inmates is prohibitively expensive. As such, current practice recommends prioritizing treatment based on clinical and incarceration-related factors. However, there is controversy about how these factors should be incorporated because of the complicated tradeoffs. In this study, we propose a modeling framework to support hepatitis C treatment prioritization decisions in U.S. prisons.

2 - Can Yardstick Competition Reduce Waiting Times?

Ozlem Yildiz, University of Virginia, Darden School of Business, Darden School of Business, Charlottesville, VA, 22903, United States, yildizo@darden.virginia.edu, Nicos Savva, Tolga Tezcan

We study whether an alternate pay-for-performance method can alleviate Emergency Department (ED) overcrowding through incentivizing socially-desired ED capacity levels, although the healthcare regulator does not know the capacity cost structure. Using yardstick competition, we propose a regulatory scheme that achieves this using the waiting time and arrival rate information of each ED.

3 - The Impact of Reimbursement Policy on Social Welfare, Revisit Rate and Waiting Time in a Public Healthcare System: Fee-for-service vs. Bundled Payment

Yulan Wang, The Hong Kong Polytechnic University, Department of Logistics and Maritime Studies, Faculty of Business, Kowloon, Hong Kong, yulan.wang@polyu.edu.hk, Pengfei Guo, Christopher S. Tang, Ming Zhao

This paper examines the impact of two reimbursement schemes, Fee-for-Service and Bundled Payment, on the social welfare, the patient revisit rate, and the patient waiting time in a public healthcare system. We find that when the patient pool size is large, the bundled payment scheme dominates the fee-for-service scheme in terms of higher social welfare and a lower revisit rate, whereas the fee-for-service scheme prevails in terms of shorter waiting time. When the patient pool is small, the bundle payment scheme dominates the fee-for-service scheme in all three performance measures.

■ SB70

S- Jefferson A

FinTech & Blockchain

Sponsored: EBusiness

Sponsored Session

Chair: Wei Chen, Tucson, AZ, 85718, United States

1 - Digital Verification and Inclusive Access to Credit: Evidence from Equifax

Xiang Hui, Washington University in St. Louis, St. Louis, MO, 63130-4899, United States, hui@wustl.edu, Tat Chan, Naser Hamdi, Zhenling Liang

We study how the digitization of employment and income verification impacts credit origination by further reducing asymmetric information over and beyond the use of credit scores. We find a disproportionate increase in loan origination and in lenders' profitability in the subprime segment, while interest rate and other loan characteristics stay similar. While the average delinquency rate increases, its impact on profitability is offset by the growth in loan origination volume. These findings are consistent with a model where instant access to verified data improves information in the market and allows for an expanded access to finance.

2 - Blockchain for Supply Chain Management: Challenges and Opportunities

Zhe Shan, Miami University, Oxford, OH, United States, Akhil Kumar, Rong Liu

In this work, we review some fundamental concepts of Hyperledger Fabric, one of the most mature permissioned Blockchain implementations. Then, we use the context of a food supply chain to highlight key design and implementation challenges for Blockchain, and provide a strategic assessment of its prospects. Our aim is to dispel misguided notions and myths about Blockchain as a silver bullet for all businesses. Our paper offers enterprises a systematic way to understand the real costs and risks of Blockchain adoption. The insights gained in the SCM context also apply to other areas such as financial services and healthcare that could leverage the full potential of Blockchain technology.

3 - Funding Open Source Software with Cryptocurrency Tokens

Wei Chen, University of Arizona, Tucson, AZ, United States, Karen Xie, Weifeng Li

Blockchain-based initial coin offerings (ICOs) allow start-ups to get funding for early-stage growth and attract open-source contribution for product development. We investigate the impact of ICOs' exchange listing on open-source contribution. The findings suggest an economically significant surge of open-source contribution following an ICO's exchange listing, which is primarily driven by external contributors rather than internal ones. Additionally, ICOs with a higher price tends to receive an influx of external contribution. These findings provide managerially relevant implications on open-source project management that is centric to blockchain-based entrepreneurship.

4 - The Effect of Secondary Market Liquidity on Primary Market Liquidity: a Natural Experiment in Peer-to-peer Lending

KAI LU, University of Science and Technology of China, Hefei, China, kailu666@ustc.edu.cn, Holden Craig, Mingfeng Lin, Zaiyan Wei, Jun Yang

We use the unexpected closure of Prosper.com's secondary market to study how secondary market liquidity affects primary market liquidity, as well as how the liquidity of one market affects that of a competing market. We show that primary market liquidity decreases for both institutional and individual loans across all levels of credit quality. Specifically, funding time increases, and funding quantity falls substantially. Moreover, credit spreads increase by approximately 90 to 130 bps for the loans most actively traded in the secondary market before its closure. We further document a spillover effect of the negative liquidity shock from Prosper to its close competitor Lending Club.

■ SB71

S- Jefferson B

Editors in Behavioral Operations Management

Emerging Topic: Behavioral Operations Management

Emerging Topic Session

1 - Editors in Behavioral Operations Management

Melanie Lisa Yeo, University of California-Merced, Merced, CA, 95343, United States

Panel session to discuss issues related to publishing behavioral operations focused papers. Topics will include views on changes in and future development of BOM research, advice for junior academics and PhD students to improve publishing success, differences between EU and US research interests/publication focus, and tips and tricks to publishing behavioral operations in journals without a behavioral division. Questions from the audience are also encouraged.

2 - POM

Elena Katok, University of Texas at Dallas, Jindal School of Management, Richardson, TX, 75080, United States

3 - MSOM, MS

Ozalp Ozer, The University of Texas at Dallas, Richardson, TX, 75080-3021, United States

4 - MSOM

Stephen Leider, University of Michigan, Ross School of Business, Ann Arbor, MI, 48109, United States

■ SB72

S- Columbia

MIF Paper Competition Award

Sponsored: Minority Issues

Sponsored Session

Chair: Lauren Berrings Davis, North Carolina A&T State University, Greensboro, NC, 27411, United States

1 - On the Distributions of Infinite Server Queues with Batch Arrivals

Jamol Pender, Cornell University, Ithaca, NY, United States, Andrew Monroe Daw

Queues that feature multiple entities arriving simultaneously are among the oldest models in queueing theory, and are often referred to as "batch" (or, in some cases, "bulk") arrival queueing systems. In this work, we study the effect of batch arrivals on infinite server queues. We assume that the arrival epochs occur according to a Poisson process, with treatment of both stationary and non-stationary arrival rates. We consider both exponentially and generally distributed service durations, and we analyze both fixed and random arrival batch sizes. In addition to deriving the transient mean, variance, and moment-generating function for time-varying arrival rates, we also find that the steady-state distribution of the queue is equivalent to the sum of scaled Poisson random variables with rates proportional to the order statistics of its service distribution. We do so through viewing the batch arrival system as a collection of correlated sub-queues. Furthermore, we investigate the limiting behavior of the process through a batch scaling of the queue and through fluid and diffusion limits of the arrival rate. In the course of our analysis, we make important connections between our model and the harmonic numbers, generalized Hermite distributions, and truncated polylogarithms.

2 - A Vector-Borne Contamination Model to Assess Food-Borne Outbreak Intervention Strategies

Jessye Talley, Morgan State University, Washington, DC, 20020, United States, Lauren Davis

Food-borne illness occurs through the consumption of food that has been tainted at some point in the food supply chain. While most contamination is accidental, there is some evidence of intentional food adulteration. This study explores the relationship between food safety practices and consumer behavior in a two-stage food supply chain. We use a vector-borne model to represent the spread of contaminated food through the supply chain. Based on our computational study,we determine the number of consumers that become ill as a result of a contamination event, describe the effect of consumer consumption and purchase behavior on the spread of food-borne illness, and evaluate the effects of various intervention strategies on consumer illness.

3 - A Two-Stage Route Optimization Algorithm for Light Aircraft Transport Systems

Shadi Sharif Azadeh, Erasmus University-Rotterdam, Rotterdam, 3062 PA, Netherlands, Michel Bierlaire, Youseef Maknoon

This paper presents a route optimization algorithm for light aircraft operating under visual flight rules. The problem aims at finding a minimum-duration, collision-free route in three spatial dimensions with possible aircraft maneuvers. The optimal route takes into account the aircraft kinodynamic characteristics and its interaction with external wind. A data processing approach is presented to recast the flying environment as a series of polyhedrons based on which a mixed-integer linear model is formulated. A two-stage route optimization model is then introduced to solve real-life instances. Computational experiments depict the efficiency of this approach.

4 - A New Epidemics-Logistic Model: Insights into Controlling the Ebola Virus Disease in West Africa

Esra Buyuktahtakin Toy, New Jersey Institute of Technology, Mechanical and Industrial Engineering Dept, Mechanical Engineering Center, Newark, NJ, 07102, United States, Emmanuel Des-Bordes, Eyyub Kibis

Compartmental models have been a phenomenon of studying epidemics. However, existing compartmental models do not explicitly consider the spatial spread of an epidemic and logistics issues simultaneously. In this study, we address this limitation by introducing a new epidemics-logistics mixed-integer programming (MIP) model that determines the optimal amount, timing and location of resources that are allocated for controlling an infectious disease outbreak while accounting for its spatial spread dynamics. The objective of this proposed model is to minimize the total number of infections and fatalities under a limited budget over a multi-period planning horizon. The present study is the first spatially explicit optimization approach that considers geographically varying rates for disease transmission, migration of infected individuals over different regions, and varying treatment rates due to the limited capacity of treatment centers. We illustrate the performance of the MIP model using the case of the 2014-2015 Ebola outbreak in Guinea, Liberia, and Sierra Leone. Our results provide explicit information on intervention timing and intensity for each specific region of these most affected countries. Our model predictions closely fit the real outbreak data and suggest that large upfront investments in treatment and isolation result in the most efficient use of resources to minimize infections. The proposed modeling framework can be adopted to study other infectious diseases and provide tangible policy recommendations for controlling an infectious disease outbreak over large spatial and temporal scales.

■ SB73

S- Boren

Topics in Fintech

Sponsored: Finance

Sponsored Session

Chair: Agostino Capponi, Columbia University, New York, NY, 10027, United States

1 - Pitfalls of Bitcoin's Proof-of-work: Research Arms Race and Mining Centralization

Humoud Alsabah, Columbia University, New York, NY, 10025, United States, hwa2106@columbia.edu

Does Bitcoin's proof-of-work (PoW) protocol serve its intended purpose of enabling and supporting a decentralized payment system? We propose a two-stage game to answer this question. Firms first invest in research and development (R&D) to subsequently compete in a mining game. We demonstrate that PoW drives the mining industry towards centralization, against the core principles of cryptocurrencies. Firms fail to capture the surplus created from their research because more research translates into a more aggressive mining game. Promoting R&D spillovers not only reduces wasteful R&D duplication and increases firms' profits, but may also improves the security of the Bitcoin system.

2 - Cross-sectional Learning of Extremal Dependence Among Financial Assets

Xing Yan, City University of Hong Kong, Kowloon, Hong Kong, yanxing128@gmail.com, Qi Wu, Wen Zhang

We separate the modeling of tail dependences of risk variables from their correlations by proposing a transformation of standard normal random vector. The resulting new random vector has distinct marginal tail heaviness. More importantly, the novelty lies in that pairwise tail dependence of any two dimensions can vary according to its own parameter rather than correlation parameter, which is an essential advantage over commonly used methods like multivariate t and elliptical distributions. It is also intuitive to interpret and easy to track comparing to the copula approach. We show its flexible tail dependence structure through simulation and verify its modeling ability in empirical studies.

3 - Crowdsourcing on the Blockchain

Gerry Tsoukalas, Wharton School of Business, Philadelphia, PA, 19104, United States, gtsouk@wharton.upenn.edu

Blockchain-based systems are increasingly using token weighted voting to crowdsource information from their users for a wide range of applications, including content curation, and on-chain governance. We examine the effectiveness of such decentralized systems at harnessing the ``wisdom" and ``effort" of the crowd.

4 - The Role of Blockchains for Modern Supply Chains

Chandra Narayanaswami, IBM Research, Yorktown Heights, NY, 10598, United States

In this talk we will cover the role of Blockchains in Supply Chain applications - including providing provenance of products using cryptoanchors for improving supply chain integrity, transparency and monitoring; improving efficiency of supply chain workflows by utilizing smart blockchain contracts for automation; protection of intellectual property such as product designs; and the role of incentives to encourage participation in Blockchain networks. The talk will also cover some lessons learned from deploying Blockchain infrastructure and networks.

■ SB74

S- Capitol Hill

JFIG Paper Competition Session I

Sponsored: Junior Faculty JFIG

Sponsored Session

Chair: Jennifer K Ryan, University of Nebraska–Lincoln, Dept of Supply Chain Management & Analytics, College of Business, Lincoln, NE, 68588-0491, United States

Co-Chair: David Goldberg, Cornell University, Ithaca, NY, 14850, United States

1 - Design of Incentive Programs for Optimal Medication Adherence

Sze-chuan Suen, University of Southern California, Los Angeles, CA, 90089-0193, United States, Diana M. Negoescu, Joel Goh

We consider how to design a schedule of incentive payments to induce optimal treatment adherence levels with heterogeneous patient preferences for adherence. A unique challenge in this problem is that any prior commitment that a patient makes to a given level of treatment adherence cannot be contracted upon, rendering existing contract-theoretic approaches ineffective. We develop new models and analyses to capture this feature and conduct a numerical study using representative data in the context of the tuberculosis epidemic in India.

2 - Value of High-Quality Logistics: Evidence from a Clash Between SF Express and Alibaba

Ruomeng Cui, NA, Decatur, GA, United States, Meng Li, Qiang Li

We study the extent to which customers value a high-quality delivery experience in online e-commerce. We exploit a natural clash between SF Express and Alibaba which resulted in Alibaba unexpectedly removing SF Express as a shipping option from Alibaba's retail platform for 42 hours in June 2017. We find that the removal of the high-quality delivery option reduced sales by 14.56% during the clash but did not impact the variety and logistics rating of sold products. We also find that the clash is more obstructive for star, expensive and less-discounted products.

3 - Dynamic Assortment Planning with Changing Contextual Information

Xi Chen, New York University, New York, NY, 10012, United States, xchen3@stern.nyu.edu, Yining Wang, Yuan Zhou

In this talk, we consider an important problem in revenue management —- dynamic assortment planning with changing feature information. Customers' utility parameters are modeled by items' feature vectors together with an unknown linear model. We present a dynamic policy for simultaneous learning preference models and maximizing expected revenues. We further establish the near-optimal regret analysis.

■ SB77

S- Fremont

Scheduling and Project Management Applications

Emerging Topic: Project Management & Scheduling

Emerging Topic Session

Chair: Rodrigo A. Carrasco, PhD, Universidad Adolfo Ibáñez, Santiago, 7941169, Chile

1 - Operating Room Scheduling under Waiting Time Constraints: The Chilean GES plan

Susana Mondschein, Universidad Adolfo Ibanez, Penalolen, Santiago, 7550000, Chile

In 2000, Chile introduced a profound health reform, establishing, among other things, a maximum waiting time between diagnosis and treatment for a set of diseases. If this is exceeded, the patient is referred to another facility and receives a voucher to cover the additional costs. With the collaboration of a Chilean hospital, we formulated a stochastic dynamic programming model to schedule surgeries in order to minimize the cost of referrals. Given the problem's size, we developed a heuristic to compute good solutions in reasonable time and analyzed its performance. Our experimental results, show that our algorithm performs close to optimum and improves upon the current practice.

2 - Optimal Decisions for Salvage Logging After Wildfires

Gianluca Baselli, Universidad Adolfo Ibáñez, Santiago, Chile, gbaselli@alumnos.uai.cl, Felipe Contreras, Matías Lillo, Magdalena Marín, Rodrigo A. Carrasco

During the summer of 2017, Chile suffered the most massive wildfires in its history, affecting many small forestry companies. In many cases, crown fires passed through forests quickly and only the tree's bark was burnt. Hence, the rest of the tree could still be harvested. The decision on how to proceed in this setting is known as the salvage logging problem: should the company make insurance claims or harvest what is left. We present a novel mixed-integer optimization-based approach to maximize the cash position of the company at the end of the harvest, considering the insurance claims, the harvesting income, and payments to workers, through an optimal workforce assignment.

3 - Setting Wait Time Targets in a Multi-Priority Patient Setting: An Inverse Optimization Approach

Vusal Babashov, PhD Candidate, University of Ottawa, Ottawa, ON, K2B 8K3, Canada, vusal.babashov@uottawa.ca, Antoine Sauré, Onur Ozturk, Jonathan Patrick

Advanced patient scheduling approaches in the Operations Research literature typically assume that wait time targets are given a priori and aim to reduce patient delays based on given priority-specific target parameters. We believe that often wait time targets are arbitrarily determined without any analytical reasoning. Consequently, patients wait longer than needed with no meaningful benefit to clinics in terms of resource management. Through this research, we have developed a rigorous analytical method to study the definition of wait time targets in a multi-priority patient setting.

4 - Application of a Resource Augmentation Algorithm for underground Mine Production Scheduling

Rodrigo A. Carrasco, Universidad Adolfo Ibáñez, Santiago, 7941169, Chile, rax@uai.cl

Mine production scheduling has been historically a very manual process, but one of great importance, since it relates extraction capacity, costs, and the economic benefits of the mining process. One of the main complexities of this schedule is the extensive collection of precedence constraints that need to be satisfied and respond to both physical limitations/requirements and capacity constraints. In this work, we present an approximation algorithm, which we apply to the mine production scheduling problem, and in particular to the underground setting. Our numerical results show that the practical performance is significantly superior to the theoretical bounds.

■ SB78

S- Greenwood

Crowds, Incentives and Management

Emerging Topic: New Product Development

Emerging Topic Session

Chair: Konstantinos Stouras, Blackrock, Ireland

1 - Risk-Return Implications of Offering Product-Service portfolio in the Software Industry

Sara Rezaee-Vessal, PhD, ESSEC, Paris, France, rezaee@essec.edu, Mehdi Nezami, Shantanu Dutta, Kapil Tuli

Drawing on a longitudinal data set of 377 publicly traded software firms, this study examines the performance effects of the service ratio, i.e., a firm's share of revenue generated from selling services, from both an accounting and a financial market perspective. Results show that the service ratio has U-shaped effects on accounting-based measures of firm risk and return, as respectively reflected in cash flow volatility and level. The service ratio also has U-shaped relationships with financial market-based measures of firm performance, as reflected in stock returns risk and firm value.

2 - Entrepreneurial Market Research: When Hypotheses Outnumber Samples

Evgeny Kagan, Johns Hopkins Carey Business School, 701 Tappan Ave, Ross School of Business, Office R5425, Baltimore, MD, 48103, United States, William S. Lovejoy, Stephen Leider

This paper investigates the search strategies for an entrepreneurial team commercializing a new technology.

3 - Designing Reward Structure for Crowdfunding Campaigns

Param Pal Singh Chhabra, Grad Student, Georgia Institute of Technology, Atlanta, GA, United States, param.chhabra@scheller.gatech.edu, Manpreet Singh Hora, Karthik Ramachandran

This study empirically investigates the association between reward structure design and performance of a crowdfunding campaign. Using data for campaigns on a crowdfunding platform, we assess parameters that are part of the reward structure design. We test the hypothesized associations and make recommendations for creators to improve campaign performance.

4 - Optimal Duration of Innovation Contests

C. Gizem Korpeoglu, Bilkent University, Ankara, Turkey, Ersin Korpeoglu, Sidika Tunc

We study optimal duration and award scheme of an innovation contest where an organizer elicits innovative solutions from agents. Each agent exerts costly effort to improve her solution and faces an output uncertainty. We find that optimal contest duration may increase with novelty and sophistication of solutions that organizer seeks. We show that an organizer with moderate or high urgency in obtaining solutions may adopt winner-take-all award scheme, while an organizer with low urgency may give multiple awards. This may explain many contests on platforms that give multiple awards. Consistent with empirical evidence, we show that optimal duration and optimal total award are positively correlated.

■ SB79

S- Issaquah A

Sustainable Growth

Emerging Topic: Sustainable Growth

Emerging Topic Session

Chair: Hayri Onal, University of Illinois, Urbana, IL, 61801, United States

1 - Productivity and Challenges in Agriculture

Canberk Ucel, The Wharton School, Philadelphia, PA, United States, ucel@wharton.upenn.edu, Marshall L. Fisher, John Paul MacDuffie

Agriculture industry demonstrated outstanding productivity growth globally, in the past half-century. These productivity gains came with sweeping technological and organizational changes. There is emerging public concern about the environmental and health effects of this unfamiliar mode of agricultural production. Despite all of its successes and controversies, there has been relatively little business scholarship evaluating modern agricultural systems. I draw lessons from The Machine that Changed the World to explore various trends and challenges in farming and agricultural supply chains, and propose directions for operations management research on this interesting industry.

2 - Land Use Optimization for Nutrient Reduction under Stochastic Precipitation Rates

Gorkem Emirhuseyinoglu, Iowa State University, Ames, IA, United States, gorkem@iastate.edu, Sarah M. Ryan

Nitrogen and phosphorus are key nutrients needed in agricultural production, but farmland runoff causes nutrient loads in waterways and reduces the oxygen level downstream by contributing to eutrophication. From the viewpoint of a policy maker concerned with regional costs and benefits, we build a multi-stage stochastic mixed-integer program for land-use decisions to maximize the agricultural profits of a watershed while meeting target reductions in nitrate and phosphorus levels under uncertain precipitation rates. Numerical sensitivity analyses reveal interactions among the nutrient reduction and labor availability constraints as well as precipitation levels and crop prices.

3 - A Dynamic Optimization Model for Renewable Energy Supply Chain Design

Raza Ali Rafique, Assistant Professor, Lahore University of Management Sciences, Lahore, Pakistan, raza.ali@lums.edu.pk, Hakeem Ur Rehman, Mohsin Nasir Jat

Growing energy demand and environmental concerns of the conventional energy production has augmented the importance of renewable energy supply systems. Recently the modeling and optimization of renewable supply chains has received a significant attention of researchers. We present an optimization model to dynamically design a cost-effective and sustainable renewable energy supply chain with the objective to increase the renewable energy share in the national energy-mix over time. Unlike the existent research, the model takes a more holistic view by considering electricity generation and distribution by managing cost and time trade-offs.

4 - Developing Sustainable Technology for Capturing Phosphorous From Agricultural Wastewater

Amir Kordijazi, University of Wisconsin-Milwaukee, Milwaukee, WI, United States, kordija2@uwm.edu

Phosphorous pollution from agricultural runoff is of concern since it is one of the main controlling factors in eutrophication that is detrimental to aqueous organs and public health. The purpose of this study is investigating use of phosphate sorbing materials (PSMs) as a cost efficient method for removal and recovery of phosphorous from agricultural runoff. To do this, results of laboratory experiments of different sorbent materials were used to develop a mathematical model of the process. Then the model was used to predict performance of different materials in actual field condition. And finally cost of removal and recovery treatment was calculated for different categories of sorbent materials.

■ SB80

S- Issaquah B

Emerging Topics in TIMES

Sponsored: Technology, Innovation Management & Entrepreneurship

Sponsored Session

Chair: Onesun Steve Yoo, University College London, London, E14 5AB, United Kingdom

1 - Smart Manufacturing via Crowd Sourcing

Onesun Steve Yoo, University College London, School of Management, United Kingdom, onesun.yoo@ucl.ac.uk, Christopher S. Tang, Kevin F. McCardle

We examine a smart crowd-sourcing model of manufacturing practiced widely by leading manufacturers in China. A key feature is the use of virtual images of their products to learn whether there is sufficient demand for them before engaging in costly physical production. Using virtual images are less attractive for consumers (uncertainty of getting the item, delays), so the firms must charge a lower price. We analyze the optimal hybrid approach that combines both use of virtual images (made-to-order) and more traditional production (made-to-stock). We compare it with the current practice of some of the leading Chinese manufacturing firms (e.g., Alibaba, Gaofan), and discuss its efficacy.

2 - The Impact of Product Diversification on Pharmaceutical Process Innovation

Ivan Lugovoi, HEC Paris, Paris, 75015, France, Dimitrios Andritsos, Claire Senot

We empirically explore the link between a pharmaceutical firm's product diversification and the qualitative characteristics of its portfolio of process innovations. We find that diversifying in related products negatively impacts both the novelty and scope of a firm's process innovation. However, diversifying in unrelated products negatively impacts the scope but positively impacts the novelty of a firm's process innovation.

3 - Luxury Brand Licensing: Free Money or Brand Dilution?

Kenan Arifoglu, University College London, Gower Street, Management Science and Innovation, London, WC1E 6BT, United Kingdom, k.arifoglu@ucl.ac.uk, Christopher S. Tang

Licensing enables luxury brands to reach out to their aspirational, low-end consumers ('followers') who value a brand more when more high-end consumers ('snobs') use it. However, over-licensing might dilute the brand for snobs who value brand exclusivity. We develop a game-theoretic model to study these two countervailing forces of licensing. Under fixed-fee licensing contract, we find that the monopolist brand should not license when snobs' desire for exclusivity is high. However, in a duopoly, fixed-fee contracts soften price competition so that licensing (even for free) is always profitable for both brands. We also study royalty contracts and compare them with the fixed-fee contracts.

4 - Workplace Environment Transparency, Employee Satisfaction, and Firm Innovation Performance

Hyunwoo Park, The Ohio State University, Columbus, OH, 43210, United States, park.2706@osu.edu, Morvarid Rahmani

We study the relationship between employee satisfaction measured in multiple dimensions and firm innovation performance measured by patenting activities. Our preliminary analysis indicates that transparency and multi-faceted employee satisfaction have mixed and nuanced relationships with innovation performance.

■ SB81

S- Kirkland

Forestry II: Forest Management and Conservation

Sponsored: Energy, Natural Res & the Environment/Forestry

Sponsored Session

Chair: Robert G Haight, US Forest Service, Saint Paul, MN, 55108, United States

1 - Crop Allocation Spatial Decision-making Using Stakeholder Engagement, Sustainability Indicators and Multi-attribute Optimization

Veronika Vazhnik, Idaho National Laboratory, Idaho Falls, ID, United States, Mohammad S. Roni, Saurabh Bansal, Jason Hansen, Tom L. Richard

Perennial crops can provide multiple benefits to agriculture including biomass feedstocks, improved water and soil quality, wildlife habitat and diversified farm income streams. Agricultural fields are spatially variable, so placing perennial grasses in environmentally and economically marginal plots within a field can improve the resilience of that landscape system. The exact placement and ratio between parts of the field with perennial and annual crops requires performing complex tradeoffs between farmers' multi-dimensional preferences. We discuss how to model these preferences using utility theory and optimize them using genetic algorithms.

2 - Optimal Planning of Multi-day Pest Surveillance Campaigns

Denys Yemshanov, Natural Resources Canada, Sault Ste. Marie, ON, Canada, denys.yemshanov@canada.ca, Robert G. Haight, Christian MacQuarrie, Frank H. Koch, Ning Liu, Robert Venette, Krista Ryall

Surveillance is critical for detecting biological invasions. We propose a model that allocates daily survey routes to detect the infestation. We adapt a team orienteering problem to plan daily inspections of biological invasions and use acceptance sampling to delimit the extent of an invasion. The inspector selects daily inspection routes, survey sites and the inspection intensities at each site. The objective minimizes the expected number of undetected infested trees subject to upper bounds on daily inspection time and the length of the survey campaign. We apply the model to surveillance of emerald ash borer in Winnipeg, Canada.

3 - Locating Watercraft Inspection Stations to Prevent Spread of Aquatic Invasive Species

Robert G. Haight, USDA Forest Service, Saint Paul, MN, 55108, United States, rhaight@fs.fed.us, Nicholas Phelps, Denys Yemshanov

Zebra mussel and starry stonewort are aquatic invasive species (AIS) that cause severe economic and ecological damage in lakes and streams in the eastern U.S. AIS spread when people move infested boats among lakes, and boat inspection at landings is the primary means of prevention. Using the location of infested and un-infested lakes, estimates of boat traffic between lakes, and likelihood of AIS establishment, we formulate an IP to locate inspection stations to minimize the likelihood of AIS establishing in un-infested lakes subject to a budget constraint. We present results that have been incorporated into AIS prevention plans for Minnesota counties.

■ SB82

S- Leschi

Challenges in Charging Electrical Vehicles

Sponsored: Energy, Natural Res & the Environment/Electricity

Sponsored Session

Chair: Luce Brotcorne, INRIA, Villeneuve D'Ascq, 59650, France

1 - A Data-driven Forecasting Model for an Aggregator of Electric Vehicles via Inverse Optimization

Ricardo Fernández-Blanco, University of Malaga, Malaga, Spain, ricardo.fcarramolino@uma.es, Álvaro Porras, Salvador Pineda, Juan Miguel Morales

We develop a data-driven forecasting model for an aggregator of electric vehicles (EVs) aiming to forecast the charging power of its fleet of EVs in the short term. The forecasting model is derived by using a data-driven inverse optimization approach based on a novel two-step estimation procedure, which requires to sequentially solve two linear programs. The resulting linear programs depend on a penalty parameter which is adjusted by using cross-validation. Finally, the behavior of the aggregated EVs is explained by using the electricity prices and historical data of driving patterns.

2 - Evaluation of Coupled Driving and Charging Incentives for Electric Vehicles

Benoit Sohet, EDF Labs, Saclay, France, benoit.sohet@edf.fr, Yezekael Hayel, Olivier Beaude, Alban Jeandin

As Electric Vehicles penetration increases, more impacts on urban systems are observed and related to both driving (e.g., on traffic congestion and reduced pollution) and charging (e.g., on the electrical grid). Therefore, there is a need to design coupled incentive mechanisms. To propose and numerically to evaluate such incentives, a game theory model is adopted. Its originality comes from the coupling between the charging cost and the driving decisions: to drive downtown or to charge at an e-Park & Ride hub with solar panels and then take public transport, in order to reach destination. Optimal ticket fares and panel surfaces are computed using real photovoltaic production data.

3 - Electric Vehicle Battery Aggregator – Multiple Market Participation

Ivan Pavic, University of Zagreb, Zagreb, Croatia

The road transport system is on a verge of complete transformation where fossil-fueled vehicles are being replaced with fully automated electric vehicles. The effect of transformation prolongs to power system as well, as it must provide timely and sufficient energy to satisfy mobility requirements. The electric vehicle users desire the lowest possible charging cost and such could be achieved by aggregated participation of vehicles on multiple power markets. This research will provide a model and results where aggregator realizes the lowest cost for its users.

■ SB83

S- Medina

Energy IV

Sponsored: Energy, Natural Res & the Environment/Electricity

Sponsored Session

1 - Time-Adaptive Unit Commitment

Salvador Pineda, University of Malaga, Malaga, 29071, Spain, spinedamorente@gmail.com, Ricardo Fernandez-Blanco, Juan Miguel Morales Gonzalez

Due to historical reasons, the unit commitment problem is solved over a time horizon consisting of the 24 hourly periods of a day. We show that, as a result of the increasing penetration of renewable generation, this arbitrary division of time may prove to be significantly suboptimal and counterproductive. Instead, we propose a time-adaptive day-ahead unit commitment formulation that better captures the net-demand variability throughout the day. Numerical results show that, without increasing the computational burden, the proposed time-adaptive unit commitment allows for a more efficient use of the system flexibility, a lower operating cost and a higher penetration of renewable production.

2 - Upgrades and Refurbishment of Power Plants under Limited Long-term Information

Andreas Kleiven, Norwegian University of Science and Technology, Alfred Getz vei 3, Trondheim, 7491, Norway, andreas.kleiven@ntnu.no, Danial Mohseni-Taheri, Selvaprabu Nadarajah, Stein-Erik Fleten, Hans Ole Riddervold

Upgrades and refurbishment of power plants with storage is a long-term planning problem affected by operations and multiple uncertainties including prices, weather and plant condition. We formulate a Markov decision process (MDP) with operational decisions, meaning the decision to produce today or delay production, and investment decisions including refurbishment timing and capacity upgrade. We handle model misspecification on long-term investments using a robust terminal value in the MDP and assess the impact of misspecification by comparing against a pure model-based approach.

3 - Optimal Power System Black-Start Planning with Damaged Communications

Amelia Musselman, Lawrence Livermore National Laboratory, Livermore, CA, United States, Ignacio Aravena

The optimal power system black-start planning problem usually assumes that energization decisions can be reliably communicated across the grid. However, the functionality of the monitoring and control network may be affected in power outages, especially in the case of cyber-attacks. We overlay a communications network on top of the power grid in order to model the impact of compromised communications infrastructure on power system black-starts. We present a specialized branch-and-cut algorithm for solving the resulting mathematical program and numerical experiments on realistic-size instances.

■ SB84

S- Ravenna A

Natural Gas Markets

Sponsored: Energy, Natural Res & the Environment/Energy Sponsored Session

Chair: Felipe A Feijoo, Chile

1 - Does the Portfolio Business Model Affect LNG Trade? A Model-based Approach

Olivier Massol, Associate Professor, IFP School, Rueil-Malmaison, 92852, France, olivier.massol@ifpen.fr

Historically the cornerstone of the LNG industry has been the long-term contract with restrictions on destination. However, market liberalization in North America and Europe and the temptation to make contracts more flexible have encouraged the rise of ‘portfolio players’ that apply trading optimization skills to derive additional value through supplying non-supply source specific LNG to buyers. We first discuss the economics of that business model to identify an adapted modeling approach. We then solve that model using standard techniques (i.e., linear programming and mixed complementarity problems). Lastly, we present the results and discuss the implications on LNG trade and LNG shipping.

2 - Co-optimized vs. Separately Optimized Natural Gas and Power Systems Considering Gas Priorities

Dan Hu, Iowa State University, Ames, IA, 50010, United States, danhu@iastate.edu, Sarah M. Ryan

The growing proportion of electric power generated from natural gas motivates greater coordination between the two energy markets. Many gas-fired generators rely on interruptible contracts with gas suppliers. The resulting uncertainty of contracted gas availability, combined with volatility in gas spot prices, can result in high wholesale electricity prices. We formulate optimization models for the day-ahead and real-time electricity markets having different types of interactions with gas market models. The role of the reliability unit commitment step in reducing overall cost is explored.

3 - GCAM-LAC: The Role of Natural Gas in South America under Climate Change Constraints

Felipe A. Feijoo, Assistant Professor, PUCV, Av. Valparaiso, Chile, felipe.feijoo@pucv.cl

We develop a detailed version of the Global Change Assessment Model (GCAM) for Latin America, called GCAM-LAC. We demonstrate the benefits of considering higher regional resolution when developing regional and country level energy and environmental policies and the role that natural gas plays in the region.

4 - A Two Stage Stochastic Programming for Natural Gas Production Planning under Chance and Conic-Flow Constraints

Andrea Arriet, Pontificia Universidad Catolica de Valparaiso, Valparaiso, Chile, andrea.arriet@pucv.cl, Felipe A. Feijoo

We developed a stochastic natural gas supply model that considers randomness in both, the sectoral demand and in the natural gas resources. Each uncertainty is handled and modeled differently. For the demand, a scenario-based approach, with associated probabilities, is taken. Uncertainty in the natural gas resources is modeled via chance-constraint optimization. Furthermore, we model the distribution network using a non-convex formulation, named Weymouth equations. Then, a relaxation technique is used to reformulate the model as a Second Order Cone Program (SOCP). The full model is solved using decomposition techniques. A case study of North America is proposed.

■ SB85

S- Ravenna B

Sustainable Energy Systems

Contributed Session

Chair: Felipe A Feijoo, Pontificia Universidad Católica de Valparaíso, Av. Brasil, Valparaíso, Chile

1 - Environment-friendly Practices and Firm Performance: The Role of Proactive Management

Anqi Wu, University of Illinois, Urbana, IL, United States, Ramanath Subramanyam

This study examines the performance of pro-environmental management initiatives in firms and the financial consequences of firm actions. We identify proactive environmental management as a strategic lever for environmentally sustainable firm behavior. Specifically, we focus on fine-grained components of proactive environmental management which help firms achieve their social responsibilities. Our results suggest that firms with a higher quality of proactive environmental management are more likely to achieve better financial performance. Further, we observe that such proactive management mitigates firms’ economic burden of reducing negative environmental impacts.

2 - Study on Environmental Performance Evaluation System for Enterprises in Regions Along the “Belt and Road”

Junrong Chen, Beijing Union University, Beijing, China, chenjunrong@buu.edu.cn

The implementation of the “Belt and Road Initiative” faces the contradiction between environmental protection and economic development. We need to build a mechanism for sharing environmental benefits and establish an environment coordination agency. In order to provide the theoretical basis for environmental institutional innovation, this paper proposes the concept of Environmental Performance Evaluation (EPE) for regional enterprises, puts forward the policy system of energy conservation and environmental protection(ECEP) that includes economic indicators

3 - Why Do Firms Adopt Costly Green Technologies

Wenqing Zhang, University of Minnesota Duluth, Labovitz School of Business and Economics, Duluth, MN, 55812, United States, Prasad Padmanabhan, Chia-Hsing Huang

There has been increased interest by a variety of stakeholders to motivate firms to invest in green technology. Given the high monetary cost of adoption of green technologies, what are the factors that can explain a firm’s decision to adopt green technologies, government subsidies notwithstanding? Using simulation models, we attempt to provide answers to the related questions. Our results show that the adoption of green technology is industry and firm specific, and may depend on the degree of competition and exposure of the firm (or industry) to the social limelight. Our results provide a partial explanation for industry and firm level differences in the degree of adoption of green technologies.

4 - Multi-modal Traffic Signal Timing Coordination

Aikaterini Deliali, PhD Candidate, UMass-Amherst, Amherst, MA, United States, adeliali@umass.edu

Previous work on the person-based optimization of signal timings for cars and buses is extended to include cyclists when bike signals are present at an intersection. The objective function of this mathematical program is the summation of delays of all users weighted by their passenger occupancy. Constraints include minimum and maximum phase duration and cycle length. The developed delay models are flexible to accommodate any number of signal phases, conflicting transit routes, and bike infrastructure treatments (e.g., bike lanes, cycle tracks, etc.).

■ SB86

S- Ravenna C

Modeling for Electricity Access

Sponsored: Energy, Natural Res & the Environment/Energy
Sponsored Session

Chair: Juan Pablo Carvallo, Lawrence Berkeley National Laboratory, CA, United States

1 - A Guide to Scalable Electricity Planning

Ayse Selin Kocaman, Bilkent University, Endustri Muhendisligi, Ankara, 06800, Turkey, selin.kocaman@bilkent.edu.tr, Simone Fobi, Jay Taneja, Vijay Modi

The lack of access to electricity in developing regions necessitates rapid and yet prudent decision making on electrification options. In this paper, we propose a set of metrics that could be used to measure the value of networked options for a given area. We subsequently demonstrate the computation of such metrics for the entire country of Kenya.

2 - Changing the Policy Paradigm: A Benefit Maximization Approach to Electricity Planning in Developing Countries

Destenie S. Nock, Carnegie Mellon University, Pittsburgh, PA, 01035, United States, destenienock5@gmail.com

Governments in emerging economies are often faced with the challenge of increasing access to electricity within budgets set by foreign aid and resource allocations. This paper develops a methodology for finding the optimal expansion of a power system under the objective of maximizing social benefit. We formulate the problem as a utility-maximization mixed integer program and apply it to Liberia. We find that a high preference for equality between rural and urban areas often leads to lower overall electricity generation, greater investment in transmission infrastructure, and wider adoption of residential solar; indifference to equality leads to the development of urban areas first.

3 - Electricity Infrastructure Development: Application for Sub-Saharan Africa

Yuang Chen, Georgia Tech, Atlanta, GA, United States, yuang.chen@gatech.edu, Valerie Thomas

Many people across the world especially in sub-Saharan Africa are still without access to electricity. This talk presents both static and dynamic electrification planning optimization models in order to advise electricity infrastructure development decisions under many constraints. The electrification planning models help to understand the balance between centralized and decentralized power investment and generation.

4 - The Economic Value of Integrating Distributed Energy Resources into Electric Utility Resource Planning

Juan Pablo Carvallo, Lawrence Berkeley National Laboratory, Berkeley, CA, United States

Distribution-transmission-generation capacity expansion model shows 10%-20% cost savings using a centralized investment and dispatch coordination for distributed resources compared to the status quo.

5 - Geospatial Electrification Planning: The REM Model

Pablo Duenas, MIT, Cambridge, MA, United States, Reja Amatya, Andres Gonzalez, Pedro Cutillas, Fernando de Cuadra, Robert Stoner, Ignacio Perez-Arriaga

The Reference Electrification Model (REM) is a computer-based optimization tool that is able to identify lowest cost system designs to most effectively provide desired levels of electricity access to populations of any given size. In doing so, the model determines the most suitable modes of electrification for each individual consumer. This software tool has been used in real planning activities in sub-Saharan Africa and South Asia. REM stands apart from other planning tools because of its high granularity and its capability to provide concrete plans for a wide range of geographical scales.

Sunday, 1:30PM - 3:00PM

■ SC01

CC- Room 201

Data Mining in Networks (Graph-based Data Mining)

Sponsored: Data Mining
Sponsored Session

Chair: Mehrnaz Amjadi

1 - Understanding Network Embedding Techniques

Yuxiao Dong, Microsoft Research, Redmond, WA, United States

Over the past few years, representation learning has been offering a revolutionary paradigm for mining and learning with network data. In this talk, I will give a systematic introduction for this ongoing paradigm shift. I will start the talk with industry examples to explain how graph mining is benefiting from representation learning. Then I will show how current developments on this problem can conceptually fall into three different categories. Importantly, I will demonstrate how these methods can be theoretically connected and unified with each other. Finally, I will show how we can leverage sparse matrix factorization for learning representations on large-scale networks.

2 - Compositional Fairness Constraints for Graph Embeddings

William Hamilton, McGill, Montreal, QC, Canada

Learning high-quality node embeddings is a key building block for machine learning models that operate on graph data, such as recommender systems. However, existing graph embedding techniques are unable to cope with fairness constraints, e.g., ensuring that recommendations do not correlate user attributes, such as age or gender. I will introduce an adversarial framework to enforce flexible fairness constraints on graph embeddings. For instance, in the context of social recommendations, our framework would allow a user to request that their recommendations are invariant to both their age and gender. Experiments on recommender system benchmarks highlight the utility of our proposed framework.

3 - Mining Graphs at Scale: Ego-networks, Clusters and Embeddings

Alessandro Epasto, Senior Research Scientist, Google, New York, NY, United States

We present recent advances in graph mining based on the analysis of local structures in graphs known as ego-nets (i.e., the subgraph induced by the neighborhood of each node). In particular, we present the Persona Graph method, a novel framework for graph analysis that allows to detect clusters in complex networks and to improve graph embedding methods. Our framework leverages ego-network analysis to disambiguate polysemous nodes in graphs and to facilitate graph embeddings. Our method is a highly scalable and flexible framework, has provable theoretical guarantees, and shows state-of-the-art results in a vast variety of ML tasks from clustering to link prediction.

4 - Spatial-Temporal Recommendation Systems

Mehrnaz Amjadi, UIC, UH2401, Chicago, IL, United States, Theja Tulabandhula

We study various approaches to exploit temporal, spatial, and hierarchical information while designing modern recommendation systems, and investigate their practical effectiveness using a hotel recommendation dataset.

5 - Bringing Knowledge Graph Semantics to Information Systems

Chenyan Xiong, Microsoft Research AI, Redmond, WA, United States

The recent development of knowledge graphs has provided semantic information with decent coverage and high quality to impact one of the most widely used AI systems—-search engine. In this talk, I will present the current state-of-the-art approaches in leveraging knowledge graphs to improve the capabilities of search engines. More specifically, I will start with a brief overview of recent developments, including the definition, construction, alignment, and utilization of knowledge graphs in real-world information systems. Then I will present a detailed example of how we leverage knowledge graph semantics to improve a deep learning system for a popular search engine task.

■ SC02

CC- Room 202

Healthcare Applications of Data Mining and Machine Learning

Sponsored: Data Mining

Sponsored Session

Chair: Akash Gupta

1 - An Initialization Procedure for the Hidden Markov Model Learning Algorithm that Supports Implementation of Multilevel Disease Progression Models

Akash Gupta, California State University-Northridge, Northridge, CA, 747075, United States, akashg@okstate.edu, Tieming Liu, Dursun Delen, Christopher Crick

Learning parameters of Hidden Markov Models (HMMs) is a computationally expensive task. In this work, we propose an initialization framework for HMM learning algorithm. The proposed procedure generates a pseudo sequence of hidden states from the observed data. Using pseudo hidden states, the initial values of the HMM parameters are derived. The results showed that the guided initialization improved the speed and time performance of the HMM learning algorithm. The proposed method facilitates the development of disease progression model with high granularity in disease states.

2 - Identify Essential Risk Factors for Diabetic Retinopathy

Ru Wang, Oklahoma State University, Stillwater, OK, United States, ru.wang@okstate.edu, Ye Liang, Tieming Liu, Zhuqi Miao

Diabetic retinopathy (DR) is a leading cause of blindness among working-aged adults globally and it's symptomless in early stages. The objective of our research is to identify essential predictors to build a cost-effective diagnosis model for early detection of DR. We performed a retrospective study based on data extracted from a large electronic health records (EHR) database. Stepwise variable selection with logistic regression and 10-fold cross validation AUC were utilized to build and evaluate the model. Ten variables were included in the diagnosis model and the AUC was 0.93.

3 - An Electronic Health Record-based Markov Decision Process Model for Sepsis Management

Sareh Meshkinfam, NC State University, Raleigh, NC, 27606, United States, Smeshki@ncsu.edu, Julie Ivy, Muge Capan, Santiago Romero-Brufau

Sepsis is the life-threatening organ dysfunction caused by a dysregulated host in response to infection. The diagnosis and treatment of sepsis is complex and uncertain as the patient's condition is dynamically changing during the diagnosis process. We develop a continuous time Markov decision process model where the state is characterized by a function of 40 EHR-based vitals and labs, and the age of the information, new or existing. We solve this model as an optimal stopping problem to determine first intervention, anti-infective or fluid, for sepsis management to reduce expected morbidity and mortality for hospitalized patients.

4 - Predicting Medical Incidents Based on EHR Data: A Knowledge-enhanced Deep Learning Approach

Qingpeng Zhang, City University of Hong Kong, Kowloon, 12180, Hong Kong, qingpeng.zhang@cityu.edu.hk, Zhongzhi Xu, Siu Fai Paul Yip

Predicting medical and clinical incidents are usually very difficult given the absence of comprehensive data about the patient's health status. In this research, we develop a novel knowledge-enhanced deep learning model that can predict self-harms (and a few other types of medical incidents) using the EHR data. We develop a comorbidity network based on historical data and then use the topological structure of the network to enhance the predicting performance. Experiments with EHR data in HK demonstrate the superior performance of the proposed method.

■ SC03

CC- Room 203

Predictive Modeling in Healthcare

Sponsored: Data Mining

Sponsored Session

Chair: David Anderson, Villanova School of Business, Villanova, PA

1 - Routing under Congestion-an Empirical Study of Triage Drift in Emergency Departments

Shuai Hao, University of Illinois at Urbana-Champaign, Champaign, IL, United States, Yuqian Xu, Zhankun Sun

Triage drift is a well-known controversy in the emergency medicine society. What is unclear is its impact on ED patient ow and other performance measures. Triage drift is observed during the process of triage score assignment as well as fast-track routing. In this work, we are particularly interested in the fast-track routing behavior under ED congestion. Our goal is three-fold. First, we want to examine the impact of ED congestion on fast-track routing decision. Second, we want to explore the outcomes of fast-track routing, and the mechanism behind those outcomes. Finally, we aim to derive potential policy implications to help improve the fast-track performance.

2 - Patient Prioritization in Cardiac Catheterization Labs

Lida Anna Apergi, University of Maryland, ISR, College Park, MD, 20742, United States, John Baras, Bruce L. Golden, Kenneth Wood

This research tackles the problem of prioritizing patients waiting to go through a cardiac catheterization lab. Considering cardiac catheterization labs in a hospital, where outpatients, inpatients, and emergency patients use the same resources, a model is designed and developed towards minimizing the patients' waiting costs. While outpatients are given a higher priority, this may change on the day of the procedure in order to improve efficiency. The model takes into account the uncertainty in the duration of each step that the patients go though as well as delays resulting from the unpreparedness of the outpatients. An Approximate Dynamic Programming approach is used to prioritize the patients.

3 - Identifying Unsuitable Doctors using Online Reviews

David Anderson, Villanova School of Business, Villanova, PA, 07030, United States, davidrybergandersong@gmail.com, Shannon Lantzy

We use data from RateMDs.com to show that online reviews can be used to predict which doctors will receive sanctions from their state medical boards in the future. We show that most of the predictive information comes from the "punctuality" rating, which can be directly observed and evaluated by patients, rather than from the "knowledge" rating, which is more of a credence attribute.

■ SC04

CC- Room 204

Recent Advances in Large-Scale Optimization

Sponsored: Data Mining

Sponsored Session

Chair: Salar Fattahi, University of California, Berkeley, CA, United States

Co-Chair: Somayeh Sojoudi, University of California-Berkeley, Berkeley, CA, 94703, United States

1 - On Local Optimality in Cubic Optimization

Jeffrey Zhang, Princeton University, Princeton, NJ, United States, Amir Ali Ahmadi

In this paper we examine local optimality in unconstrained cubic optimization. We give a characterization of when a point is a strict or nonstrict local minimum of a cubic polynomial, and show that these characterizations are checkable in polynomial time. We then address the problem of finding local minima of cubic polynomials.

2 - Low-complexity and Massively Parallelizable Convex Relaxations

Ramtin Madani, Assistant Professor, The University of Texas at Arlington, Arlington, TX, 76015, United States, ramtin.madani@uta.edu, Muhammad Adil

In this talk, we introduce convex relaxations and numerical algorithms with an unprecedented level of scalability to accommodate nonlinear functions and integer variables. In lieu of local search algorithms, computationally demanding relaxations, and linearization techniques, we pursue novel low-complexity relaxations that are fundamentally more efficient compared to the state-of-the-art methods for nonlinear optimization. Lastly, a highly parallelizable numerical method is introduced that can leverage GPUs and distributed computation platforms with orders-of-magnitude time improvements.

3 - Learning Large-scale Sparse Graphical Models: Theory and Algorithm

Salar Fattahi, University of California, Berkeley, Berkeley, CA, 94702, United States, fattahi@berkeley.edu, Somayeh Sojoudi

Graphical Lasso (GL) is a popular method for learning the structure of graphical model, which is based on an l-1 regularization technique. The existing algorithms are incapable of solving high-dimensional instances of the problem. The major impediment to the scalability of the current solvers is their expensive runtime; the fastest known algorithm for the GL has complexity O(n^4). We ask the following somewhat ambitious question: can we reduce the complexity of solving the GL from O(n^4) to O(n^2)? In this work, we provide an affirmative answer to this question. In particular, we provide a class of algorithms with near-quadratic time complexity that can obtain a near-optimal solution to the GL.

4 - Implicit Deep Learning

Laurent El Ghaoui, Professor, UC Berkeley, Berkeley, CA, 94703, United States, Fangda Du, Armin Askari, Bertrand Travacca

We define a new class of “implicit” deep learning prediction rules that generalize the recursive rules of feedforward neural networks. These models are based on the solution of a fixed-point equation involving a single a vector of hidden features, which is thus only implicitly defined. The new framework greatly simplifies the notation of deep learning, and opens up new possibilities, in terms of novel architectures and algorithms, robustness analysis and design, interpretability, sparsity, and network architecture optimization.

5 - Some Advances in Distributed and Multistage Optimization

Andy Sun, Georgia Institute of Technology, Atlanta, GA, 30332-0205, United States

Multistage dynamics, nonconvex, and distributed computation jointly pose some very challenging computational problems for optimization. In this talk, we overview some recent advances in efficient computational methods for solving a broad class of challenging distributed nonconvex optimization problems.

■ SC05

CC- Room 205

Disaster and Emergency Management III

Contributed Session

Chair: Girish Chandra Dey, IIT Khargpur Campus, IIT Khargpur Campus, Kharagpur, 721302, India

1 - Time-critical Deficits in Cross-border Information Exchange: An Agent-based Study of Cross-national Crisis Cooperation

Miriam Klein, Karlsruhe Institute of Technology, Karlsruhe, Germany, miriam.klein@kit.edu, Marcus Wiens, Frank Schultmann

Historical natural disasters that occurred across national borders highlighted the yet untapped potential of cross-border collaboration. In particular, the timely exchange of information proofed to be crucial. In this contribution, we develop an agent-based model to analyze information flows between citizens and crisis response actors organizing the distribution of essential goods. By quantifying the information delays due to misunderstandings and mistrust among the actors from both sides of the border, our model provides critical insights into the strategic planning phase in crisis response.

2 - Optimization Model for Allocating Emergency Vehicles with Integration Dispatch

You Zhao, Kansai University, Osaka, Japan, k819381@kansai-u.ac.jp, Hiroshige Dan

In this research, we consider an optimization problem for allocating and dispatching emergency vehicles (EVs). First, we developed an optimization model which considers the integration dispatch of EVs in a large area. We generated some random scenarios to deal with uncertainty in the real world and conducted numerical experiments. However, we found that our model may fail to find the optimal solution by using optimization solvers. Therefore, we modified the model to fix the allocation of EVs and the modified model can find the optimal or nearly optimal dispatch under the fixed allocation.

3 - Analyzing Effectiveness of Prescribed Fires in the United States

Laura Devine, University at Buffalo, Buffalo, NY, United States, Esther Jose, Jun Zhuang

Prescribed fires are increasingly being used as a countermeasure to the rising intensity of prescribed fires in the United States of America: Prescribed fires have been carried out by more than 48 states in the USA- more than 100,000,000 acres in prescribed fires have been burned from 2003-2017. To the best of our knowledge, there has been no study on the effectiveness of these prescribed fires in decreasing intensity of wildfires. In this paper, we study the effectiveness of prescribed fires based on data from 2003-2017 and construct a linear optimization model to minimize the costs associated with prescribed fires while also decreasing the intensity of wildfires.

4 - New Information Infrastructure for Handling the Opioid Epidemic - A Blockchain Perspective

Wei Chen, Assistant Professor, York College of Pennsylvania, York, PA, United States, wchen@ycp.edu, Benjamin V. Neve

The U.S. is in the midst of an unprecedented opioid crisis, where the number of deaths due to opioid overdoses continue rising. U.S. Counties, tasked with front-line response to the epidemic, create their own information systems to monitor opioid overdose patients. Most systems are fragmented among the several providers and government agencies, and they lack effective communication mechanisms. We propose a new information infrastructure system that integrates all current systems under a blockchain framework. The proposed system provides interoperability and transparency for patients, providers and government agencies, as well as maintains compliance with federal privacy laws.

5 - Dynamic Fortification Decisions of Hierarchical Healthcare Facilities Against Intentional Disruptions

Girish Chandra Dey, IIT Kharagpur, Kharagpur, India, deygirish@gmail.com, Mamata Jenamani

This paper dynamically allocates the fortification resources among the critical hierarchical healthcare facilities to minimize the impact of worst-case disruptions. The problem is formulated as a bi-level mixed-integer program and solved by super valid inequalities based decomposition algorithm. Computational results of a case study on the healthcare system in Malkangiri district of Odisha, India are analyzed for efficient fortification decisions.

■ SC06

CC- Room 209

Data Analytics in Semiconductor Manufacturing

Sponsored: Data Mining

Sponsored Session

Chair: Dohyun (Norman) Kim, Myongji University

1 - Improving Interpretability in Deep Learning Models for Semiconductor Manufacturing

Sangyong Lee, Myongji University, Korea, Republic of, sangyonglee@mju.ac.kr, Eunji Jo, Dohyun (Norman) Kim

Many studies using deep neural networks (DNNs) have been performed in semiconductor manufacturing processes. However, one of the major drawbacks of the DNN model is that it is not easy to explain which variables are more important. The purpose of this study is to explain the importance of variables in a DNN model and to improve the model’s ability to interpret.

2 - Virtual Metrology on Thin Film Deposition Process for Semiconductor Fabrication

Jeongeun Choi, Myongji University, Yongin, Korea, Republic of, wjddms1353@naver.com, Sangjeen Hong

Stringent process control with precise metrology is a key to success in current nano-scale semiconductor manufacturing. To ensure the quality of the fabricated devices, a large number of metrology steps are required; however, it increases the cost and throughput. In this research, simple neural networks are employed to enhance the understanding of the thin film deposition process and its physical and chemical mechanism in plasma as a mean of virtual metrology. Established neural network model is capable of the prediction of the deposited film thickness of amorphous carbon layer in plasma enhanced chemical vapor deposition process.

3 - Decomposition of Variance Based on Transmissions in Multi-stage Process: A Study on the Semiconductor Industry

Bokyoung Kang, Samsung, Hwasung, Korea, Republic of, by.kang@samsung.com

Conventional applications of data mining algorithms have been suggested to identify critical metrology variables in semiconductor manufacturing process, but they commonly have assumed an one-stage model irrelevant to orders, which can cause impractical interpretations. To improve such limitations, this paper proposes a variance propagation through multi-stages manufacturing process by series metrology based variance transmission modeling. The proposed approach models linear relationships between metrology variables corresponding to physical orders upon the multi-stage process flows, and then independently decomposes the influence of each variable to the total variance of output.

4 - Deep Learning-based Clustering for Identifying Defective Wafer Maps

Dohyun (Norman) Kim, Myongji University, Yongin si, Korea, Republic of, ChulHee Lee

Wafer maps are used to visualize defect patterns and identify potential process issues in semiconductor manufacturing. Wafer map defective pattern clustering can assign defects to similar types, allowing engineers to focus on the cause of each type of defect. This study proposes a deep learning-based clustering algorithm for mapping defective wafer patterns to low dimensions and clustering them simultaneously.

■ SC07

CC- Room 210

Approaches and Applications in Social Networks and Service

Sponsored: Data Mining

Sponsored Session

Chair: Zhen Xu

1 - Adaptive Influencer Marketing with Intermediary Constraints

Shatian Wang, Columbia University, New York, NY, 10027, United States, sw3219@columbia.edu, Zhen Xu, Van-Anh Truong

We consider the scenario in which a brand promotes a product over multiple rounds of influencer marketing on a social network, with the goal of reaching the maximum number of users in the network. Our problem is closely related to the adaptive influence maximization problem. However, we introduce a novel constraint that limits the number of times an uncompensated user will help spread the product information. This constraint, while more realistically captures user behaviors, adds challenges to the analysis. We also assume that the brand needs to learn the parameters of the underlying influence diffusion model over time. We propose an online learning algorithm and give regret guarantees.

2 - A Scalable Sparse Completely Positive Relaxation of the Modularity Maximization for Community Detection

Junyu Zhang, University of Minnesota Twin Cities, Minneapolis, MN, United States, zhan4393@umn.edu

We consider a community detection problem for social networks which is often solved by an NP-hard modularity maximization formulation. We propose a sparse and low-rank completely positive relaxation for modularity maximization problem and then develop an efficient block coordinate descent algorithm to solve the relaxation. A fast rounding scheme is constructed to retrieve the community structure from the solution. Non-asymptotic high probability bounds on misclassification rate are established under proper assumptions. Extensive experiments on both synthetic and real-world networks show that the proposed approach enjoys advantages in both clustering accuracy and numerical efficiency.

3 - Online Learning and Recommendation with Linear Threshold Model

Shuoguang Yang, Columbia University, New York, NY, 10027, United States

We consider a variation of influence maximization problem on the social network. We first propose a linear threshold model-based diffusion processes that obtains monotonicity and submodularity. We then develop an online learning algorithm which learns the diffusion parameter by past observations, and give suboptimal recommendations based on the current information learnt. We conduct regret analysis and give a theoretical guarantee on the average regret of the algorithm. We conduct numerical experiments to support our theoretical results.

4 - Prediction and Risk Stratification of Surgical Site Infection

Zhenhuan Zhang, PhD Candidate, University of Minnesota, Minneapolis, MN, 55414, United States, Mustafa Y. Sir, Kalyan Pasupathy, Diana Maria Negoescu, Priya Sampathkumar, John O'Horo

Surgical Site Infections are one of the most common healthcare-associated infections, accounting for $3.2 billion attributable healthcare cost per year in the United States. It is also the most frequent cause of unplanned readmissions after surgery. With Mayo Clinic five-year inpatient surgery data, we first performed univariate descriptive analysis, and then applied various machine learning techniques (logistic regression, random forest, boosting and SVM), and casual-inference modeling techniques (covariate matching, casual tree, two-stage OLS) to predict, and stratify SSI risk.

■ SC08

CC- Room 211

Joint Session AI & ML/Practice Curated: Applications of AI and ML in Supply Chain Management

Emerging Topic: Artificial Intelligence & Machine Learning

Emerging Topic Session

Chair: Lawrence V Snyder, Lehigh University, Bethlehem, PA, 18015-1582, United States

1 - Can Deep Reinforcement Learning Improve Inventory Management? Performance and Implementation of Dual Sourcing-mode Problems

Joren Gijsbrechts, KU Leuven, Leuven, Belgium, joren.gijsbrechts@kuleuven.be, Robert Boute, Jan A. Van Mieghem, Dennis Zhang

The popularity of reinforcement learning is growing but is it effective in operations? We provide proof of concept that deep reinforcement learning (DRL) can be applied to classic, yet intractable dual-sourcing or dual-mode inventory replenishment problems. Step-by-step guidance on how to apply DRL to a real data set is proffered together with the code and a careful discussion of its performance, strengths and weaknesses.

2 - Blockchain Based Visibility and Supply Chain Gains

Pavithra Harsha, IBM Research, Yorktown Heights, NY, United States, Ajay Deshpande, Ali Koc, Ashish Jagmohan, Brian Quanz

Blockchain enables ability to share network state information by various actors in a supply chain. We simulate various inventory policies based on information shared by different actors and demonstrate gains in supply chain in terms of demand loss, inventory waste and inventory freshness.

3 - A Practical End-to-end Inventory Management Model with Deep Learning

Meng Qi, University of California, Berkeley, Berkeley, CA, 94704, United States, Yuanyuan Shi, Chenxin Ma, Rong Yuan, Di Wu, Max Shen

We investigate the data-driven multi-period inventory replenishment problem with uncertain demand and vendor lead time. Different from the traditional two-step predict-then-optimize (PTO) solution framework, we propose an end-to-end (E2E) framework that uses deep-learning models to output the suggested replenishment amount directly from input features without any intermediate steps. By conducting a series of numerical experiments using real data from JD.com (one of the leading e-commerce companies), we demonstrate the advantages of the proposed E2E model. For industry, our E2E model provides an automatic inventory management solution with the possibility to generalize and scale.

4 - Shaping Inventory Control via Reinforcement Learning

Reza Nazari, Lehigh University, Murray H. Goodman Campus, Bethlehem, PA, 18015, United States, mon314@lehigh.edu, Lawrence V. Snyder, Martin Takac

Student-teacher reinforcement learning (RL) is a new framework in which an RL agent learns to maximize its reward while also not deviating too much from a "teacher" policy. We apply student-teacher RL to a variety of single-stage inventory optimization problems. We show that RL can handle various types of uncertainties and cost structures that are difficult to address using classical inventory optimization methods. We use continuous-action policy gradient methods as our main training algorithms. We show that student-teacher RL can shape the inventory policy to be similar to base-stock or other policies that managers find intuitive or otherwise desirable.

■ SC09

CC- Room 212

AI for Business Intelligence

Sponsored: Artificial Intelligence

Sponsored Session

Chair: Jingyuan Yang, George Mason University, Fairfax, VA, 22030, United States

1 - One Side Does Not Fit All: Personal Match and Marketing Message Effectiveness on Social Networks

Yuan Qu, Rutgers University, Newark, NJ, 07102, United States, yuan.qu@rutgers.edu, Jingyuan Yang

The goal is to improve participation and eventually marketing effectiveness of this kind of marketing (group marketing) according to user-article match. Technique-wise, this is a new problem compared to existing work. A traditional problem setting usually looks for a good match between users and product, and the goal is to maximize user interest in the product. Here our problem is the user and product match which leads to marketing effectiveness.

2 - More is More? understanding the Effect of Consumer Complaint Properties

Ramah Al Balawi, University of Illinois at Chicago, Chicago, IL, United States, Yuheng Hu

In this working project, we aim to understand how firms' complaint practices are affected by changes in customers' complaint properties on social media. We make use of a design change implemented by Twitter in which a message (tweet) character limit was increased from 140 to 280 characters to understand how complaint properties influence firm responses.

3 - To Be or Not To Be Friends: Exploiting Social Ties for Venture Investments

Hao Zhong, Rutgers University, Newark, NJ, United States, zhhao31@gmail.com

From both financial and managerial perspectives, decision-making process and successful rates of venture capital (VC) investments can be greatly improved if the investors well know team members of target startups. However, not much efforts have been made on understanding the impact of prominent social ties between members of VC firms and start-up companies on investment decisions. To this end, we propose to study social relationships and see how it can contribute to foreseeing potential investment deals. We aim at providing analytical guidance for the venture capitalists in choosing right investment targets, by developing a Social-Adjusted Probabilistic Matrix Factorization (PMF) model.

4 - Smart Driving for Smart City: The Theory and Solutions of Multi-user Mobile Sequential Recommendation

Zeyang Ye, Stony Brook University, College of Business, Stony Brook, NY, 11794, United States, Keli Xiao, Yong Ge

Smart cruising strategies for taxi drivers significantly reduce the traffic pressure for the cities. They are studied by the mobile sequential recommendation (MSR) problem. For a single user, we develop new methods to provide a real-time search for the optimal route, which reduces the computational time from days to seconds. For multi-user, the direct accumulations of the single-user solutions lead to a significant increase in the computation time and overlapped recommendations. We develop new parallel methods, which again reduces the time from hours to seconds. We also develop a theory for MSR to unify the original form and its variations and make the hyperparameters auto-adjusted.

5 - A Hierarchical Career-Path-Aware Neural Network for Job Mobility Prediction

Qingxin Meng, Rutgers University, Piscataway, NJ, United States

The understanding of job mobility can benefit talent management operations in a number of ways, such as talent recruitment, talent development, and talent retention. While there is extensive literature showing the predictability of the organization-level job mobility patterns (e.g., in terms of the employee turnover rate), there are no effective solutions for supporting the understanding of job mobility at an individual level. To this end, in this paper, we propose a hierarchical career-path-aware neural network for learning individual-level job mobility. Specifically, we aim at answering two questions related to individuals in their career paths: 1) who will be the next employer? 2) how long will the individual work in the new position? Specifically, our model exploits a hierarchical neural network structure with embedded attention mechanism for characterizing the internal and external job mobility. Also, it takes personal profile information into consideration in the learning process. Finally, the extensive results on real-world data show that the proposed model can lead to significant improvements in prediction accuracy for the two aforementioned prediction problems. Moreover, we show that the above two questions are well addressed by our model with a certain level of interpretability. For the case studies, we provide data-driven evidence showing interesting patterns associated with various factors (e.g., job duration, firm type, etc.) in the job mobility prediction process.

■ SC10

CC- Room 213

CAP/aCAP Overview

Sponsored: Analytics

Sponsored Session

Chair: Heather Trusty, INFORMS, Catonsville, MD, 21228, United States

1 - CAP/aCAP Overview

Heather Trusty, INFORMS, Catonsville, MD, 21228, United States

Revisit Heuristics for Flowhsop Scheduling with Availability Constraint

■ SC11

CC- Room 214

Applied Probability Models for Service Systems

Sponsored: Applied Probability

Sponsored Session

Chair: Carri Chan, Columbia Business School, New York, NY, 10027, United States

Co-Chair: Noa Zychlinski, Technion - Israel Institution of TechnologyHaifa, 34354, Israel

1 - Process Flexibility for Multi-period Production Systems

Yuan Zhong, University of Chicago / Booth School of Business, 5807 S. Woodlawn Avenue, Chicago, IL, 60637, United States, yuan.zhong@chicagobooth.edu, Cong Shi, Yehua Wei

We consider process flexibility in a multi-period make-to-order production (MTO) system. First, using a new chaining notion, termed the Generalized Chaining Gap (GCG), we prove that in a general system with high utilization, a sparse flexibility structure with m+n arcs is needed to achieve similar performance as full flexibility, where m and n are the number of plants and of products, respectively. We also provide a simple and efficient algorithm for finding such sparse structures. Moreover, we show that the requirement of m+n arcs is necessary, as for some systems, even the best flexibility structure with m+n-1 arcs cannot achieve the same asymptotic performance as full flexibility.

2 - Shift Effect in Emergency Departments

Tianshu Lu, University of Toronto, 105 St. George Street, Toronto, ON, M5S 3E6, Canada, Tianshu.Lu15@Rotman.Utoronto.Ca, Dmitry Krass, Opher Baron

We study how a self-interested physician in an emergency department (ED) allocates her capacity between new patients and re-entrant patients, focusing on the time-dependent behavior pattern. For the physician, we characterize her optimal strategy; for the ED manager, we show the undesirable effect of physician’s strategy on time to physician initial assessment (TPIA). We analyze physician’s strategy by using MDP, and analyze its impact with a fluid queueing model. In MDP, we show that physician’s strategy is of two phases: in the first, the physician is more willing to serve new patients, while re-entrant in the second. In the fluid model, we show that the p-th (p>50) percentile of TPIA becomes longer.

3 - Adaptive Task Replication in Data Centers: A Robust Queueing Approach

Chaithanya Bandi, 1987, Evanston, IL, 60208, United States, c-bandi@kellogg.northwestern.edu

Replication is a widey used approach for reducing delays in multi-server distributed queueing systems. The idea behind replication is that customers can greatly reduce response time by waiting in multiple queues at the same time, thereby experiencing the minimum time across queues. In this talk, we leverage on Robust Queueing and Multi-stage robust optimization to design optimal adaptive routing policies. In particular, we model the adaptive replication problem as a finitely adaptive two stage robust optimization and present the structure of the optimal solution.

4 - Managing Queues with Different Resource Requirements

Noa Zychlinski, Columbia Business School, Israel, NYC, NY, 34354, United States, nz2307@columbia.edu, Carri Chan, Jing Dong

We propose a multi-server queueing model with multiple customer classes, where customers may require different amount of resources to be served. This model is motivated by healthcare settings in which clinical guidelines suggest classifying the patients based on the level of medical attention/supervision they require. We show that and index-based policy, which accounts for customer’s dis-utility of waiting, expected service time, and resource requirements, is optimal in several settings. Additionally, we show that an idle-aware variant of our proposed policy exhibits several properties that make it desirable for use in practice.

■ SC12

CC- Room 2A

Bandits and Reinforcement Learning

Sponsored: Applied Probability

Sponsored Session

Chair: Christina Lee Yu, Cornell University, Ithaca, NY, 14853, United States

1 - Correlated Multi-armed Bandits with a Latent Random Source

Gauri Joshi, Carnegie Mellon University, Pittsburgh, PA, United States

We consider a novel multi-armed bandit framework where the rewards obtained by pulling the arms are functions of a common latent random variable. The correlation between arms due to the common random source can be used to design a generalized upper-confidence-bound (UCB) algorithm that identifies certain arms as non-competitive and avoids exploring them. As a result, we reduce a K-armed bandit problem to a C+1-armed problem, where C+1 includes the best arm and C competitive arms. As a result, there are regimes where our algorithm achieves an O(1) regret as opposed to the typical logarithmic regret scaling of multi-armed bandit algorithms.

2 - On Reinforcement Learning Using Monte Carlo Tree Search with Supervised Learning: Non-asymptotic Analysis

Qiaomin Xie, Cornell University, Ithaca, NY, United States, Devavrat Shah, Zhi Xu

AlphaGo Zero (AGZ) introduced a new reinforcement learning algorithm that has achieved superhuman performance in the game of Go. A key innovation is use of Monte-Carlo Tree Search (MCTS) with Supervised Learning (SL) for learning the policy. We shall argue that MCTS with expressive enough SL learns the optimal solution at nearly minimax optimal rate. This is the first complete and rigorous non-asymptotic analysis of MCTS. We correct a fundamental error in the well cited MCTS algorithm and its proof. Interestingly, the AGZ had already utilized this correction in its implementation. Our results hold for both infinite horizon MDPs as well as two-player Markov games.

3 - Mostly Exploration-free Algorithms for Contextual Bandits

Khashayar Khosravi, Stanford University, Stanford, CA, United States, khosravi@stanford.edu, Hamsa Sridhar Bastani, Mohsen Bayati

The contextual bandit literature has focused on algorithms that address the exploration-exploitation tradeoff. Exploration-free greedy algorithms are desirable in settings where exploration may be costly or unethical. We prove that, under some assumptions on the distribution of the contexts, the greedy algorithm is rate-optimal for the two-armed bandit. Also, even absent these assumptions, we show that a greedy algorithm is optimal with nonzero probability. Thus, we introduce Greedy-First, an algorithm that uses only observed contexts and rewards to decide whether to follow a greedy algorithm or to explore. Greedy-First is rate-optimal without any additional assumption.

4 - Coordinated Exploration in Concurrent Reinforcement Learning

Maria Dimakopoulou, Netflix, Los Gatos, CA, United States

We consider a team of reinforcement learning agents that concurrently learn to operate in a common environment. We identify three properties - adaptivity, commitment, diversity - which are necessary for efficient coordinated exploration and we propose seed sampling, a posterior sampling algorithm that satisfies them. We proceed to design concurrent reinforcement learning algorithms that achieve these three properties in real systems with potentially enormous state spaces, where tabular methods do not scale. There is a multitude of commercial applications that can benefit from this algorithmic framework, ranging from recommendation systems, to robot automation, to self-driving cars.

■ SC13

CC- Room 2B

Mean Field Games and Applications

Sponsored: Applied Probability

Sponsored Session

Chair: Daniel Lacker, Columbia University, New York, NY, 10027, United States

1 - The Social Planner Problem with Finite State Space

Asaf Cohen, University of Michigan, Ann Arbor, MI, 48103, United States, shloshim@gmail.com, Erhan Bayraktar

We consider a finite state continuous-time social planner problem with weakly interacting symmetric N agents. The social planner controls the rate of transition of the agents, aiming to minimize a cost. In addition to the control, agents move from one state to another according to an external force; both the transition rates and the cost depend on the empirical distribution of the agents over the states. We set up a (limiting) diffusion control problem whose set of optimal controls is exactly the set of all the limit points of all the asymptotic optimal control sequences in the N-agent problem. Moreover, we show a possible connection between the limiting problem and a nonlinear Kimura PDE.

2 - Pareto Optimality Versus Nash Equilibrium, Price of Anarchy Versus Price of Stability

Xin Guo, University of California-Berkeley, Piedmont, CA, 94611, United States, xinguo@berkeley.edu, Renyuan Xu

Pareto optimality (PO) is an important concept in game theory to measure the global efficiency when players collaborate. In this talk, we start with the PO for a class of continuous-time stochastic games with finite number of players. To explicitly solve for a PO, we consider a central controller who coordinates the system and transform the problem into a sequence of Skorokhod problems. We then discuss the PO with infinity number of players, which leads the McKean-Vlasov dynamics. Another common criterion in game theory is the Nash equilibrium (NE) which captures the stability under competition. In the end, we compare the PO solution with the NE via price of stability and price of anarchy.

3 - Many-player Games of Optimal Consumption and Investment under Relative Performance Criteria

Agathe Soret, Columbia University, New York, NY, 10027, United States, acs2298@columbia.edu, Daniel Lacker

We study a portfolio optimization problem for competitive agents with CRRA utilities and a common finite time horizon. The utility of an agent depends not only on her absolute wealth and consumption but also on her relative wealth and consumption when compared to the averages among the other agents. We derive a closed form solution for the n-player game and the corresponding MFG, which is unique in the class of equilibria with constant investment and continuous time-dependent consumption. Compared to the classical Merton problem with one agent, the competitive model exhibits a wide range of highly nonlinear and non-monotone dependence on the agents' risk tolerance and competitiveness parameters.

4 - Stochastic Graphon Games: The Static Case

Mathieu Lauriere, Princeton University, Princeton, NJ, 08540, United States, Rene Carmona, Daniel Cooney, Christy Graves

We introduce a class of static games with a continuum of players as limits of finite player static games for which players get idiosyncratic random signals. We analyze the limits as graphon games and we emphasize the differences with static mean field games.

■ SC14

CC- Room 302

Auctions and Mechanism Design

Sponsored: Manufacturing & Service Oper Mgmt

Sponsored Session

Chair: Gabriel Weintraub, Stanford Graduate School of Business, Stanford, CA, 94304, United States

1 - Supplier Competition and Investment: An Experimental Investigation

Cuihong Li, University of Connecticut, School of Business, Storrs, CT, 06269, United States, cuihong.li@uconn.edu, Elena Katok, Zhixi Wan

We consider a buyer facing two suppliers who invest in cost reduction before bidding for contracts. Using laboratory experiments, we investigate how supplier competition and investment observability affect suppliers' cost-reduction effort and buyer's reserve price decisions.

2 - Pay-as-Bid Procurement Mechanisms for Differentiated Products

Je-ok Choi, Stanford University, Stanford, CA, 94305, United States, jchoi89@stanford.edu, Daniela Saban, Gabriel Weintraub

The rules of public procurement mechanism must be simple and transparent. In practice, this typically results in such mechanisms being implemented as pay-as-bid (or first price) auctions. In this work, we consider the mechanism design problem of finding an optimal pay-as-bid mechanism that balances two objectives of the procurement agency: purchasing at low prices and providing enough variety in an assortment to accommodate heterogeneous buyers. On a stylized Hotelling model, we show the optimality of a simple class of assortment mechanisms called soft reserve rules. We also provide evidence of the robustness of soft reserves and of their performance under more general demand models.

3 - Position Ranking and Auctions for Online Marketplaces

Leon Chu, USC Marshall School of Business, University Park Campus, Los Angeles, CA, 90089, United States, leonyzhu@usc.edu, Hamid Nazerzadeh, Heng Zhang

Online e-commerce platforms such as Amazon and Taobao connect thousands of sellers and consumers every day. In this work, we study how such platforms should rank products displayed to consumers and utilize the top and most salient slots. We present a model that considers consumers' search costs and the externalities sellers impose on each other. This model allows us to study a multi-objective optimization, whose objective includes consumer and seller surplus, as well as the sales revenue, and derive the optimal ranking decision. In addition, we propose a surplus-ordered ranking (SOR) mechanism for selling some of the top slots. This mechanism is motivated in part by Amazon's sponsored search program.

4 - Information Design in Dynamic Contests

Mohamed Mostagir, University of Michigan, Ann Arbor, MI, 48109, United States, Yan Chen

Contests are usually modeled as all-pay auctions, with the majority of existing results corresponding to static one-shot auctions where participants make a single decision about their effort levels ("payments"). This paper considers these contests in a dynamic setting, where the question of how to provide information over time becomes important for extracting the maximum effort from participants. We design a novel experiment that examines how subjects behave in the lab under different information mechanisms, and detail the advantages and disadvantages of these mechanisms for both the designer's objective as well as the welfare of participants.

■ SC15

CC- Room 303

Customer Behavior and Information in Service Systems

Sponsored: Manufacturing & Service Oper Mgmt

Sponsored Session

Chair: Tamer Boyaci

Co-Chair: Caner Canyakmaz, ESMT Berlin (European School of Management and Technology), Berlin, 10178, Germany

1 - Service Systems with Rationally Inattentive Customers

Caner Canyakmaz, ESMT European School of Management and Technology, Berlin, 10178, Germany, caner.canyakmaz@esmt.org, Tamer Boyaci

Many service systems are “opaque” in that customers cannot discern precise queue lengths upon arrival due to information frictions and/or cognitive restrictions. We model this using rational inattention theory and develop a strategic queuing framework that naturally bridges observable and unobservable queues. Customers optimally select the type and quantity of information they need and ignore information that is not worth obtaining in an endogenized information acquisition process, trading-off the benefits of better information against its cost (measured as the reduction in Shannon entropy). We characterize equilibrium behavior and demonstrate throughput/welfare implications.

2 - Efficient Inaccuracy: User-generated Information Sharing in a Queue

Jianfu Wang, Nanyang Business School, Nanyang Technological University, Block S3-B2C-85, 50 Nanyang Avenue, Singapore, 639798, Singapore, Ming Hu

We study a service system which does not have the capability of monitoring and disclosing its real-time congestion. However, customers can observe and post their observations online. Future arrivals can take into account such user-generated information when deciding whether to go to the service facility. We perform pairwise comparisons of the shared, full, and no queue length information structures in terms of social welfare. We show that a little, inaccurate and lagged, shared queue length information can go a long way and that it may be more socially beneficial to encourage the sharing of user-generated information among customers than to provide them with full real-time queue length information.

3 - Pay What You Want Pricing under Demand Learning

Haoyu Liu, HKUST, Clear Water Bay, Kowloon, 999077, Hong Kong, haoyu.liu@connect.ust.hk, Ying-Ju Chen

We explore the possibility of adopting Pay What You Want (PWYW) pricing as a selling strategy when the consumers’ valuation is unknown. We compare PWYW with two benchmarks where the firm uses either a fixed price or dynamic pricing and identify the conditions under which PWYW achieves superior performance to other selling strategies. We show that when the consumers are myopic, PWYW always dominates the fixed price (FP) policy. More interestingly, when the consumers are strategic, PWYW dominates Pay As Asked (PAA) when the generosity level is above a threshold, and the threshold is decreasing in cost. We also discuss several potential directions for the firm to improve its profitability.

4 - Designing Digital Rollovers: Managing Obsolescence through Release Times

Esma Koca, Imperial College London, PhD Student, Postbox, Tanaka Building, London, SW2 7AZ, United Kingdom

When releasing a new product, a firm tries to attract new customers and persuade existing customers to upgrade. This is achieved through a rollover, which compromises the price of the new product and the decision to cease the sale of the old product (solo) or to sell the old product at a discount (dual). The release timing of the new product is a commonly overlooked third lever. It influences the consumers’ perception of obsolescence, by which an old product is considered obsolete merely by reference to a new product. We show that the release time enables the firm to induce its customers, strategic or not, to upgrade so that a solo rollover is optimal.

5 - Omnichannel Queue with Partial Information

Yuting Yuan, Simon Business School, University of Rochester, University of Rochester, Rochester, NY, United States, yuting.yuan@simon.rochester.edu, Ricky Roet-Green

Numerous retailers have adopted online order technology as a complement to their existing offline physical stores. In this paper, we study the impact of such omnichannel service system on consumers’ queueing strategies, operator’s revenue, and social welfare. In our model, a firm serves two streams of arriving consumers (online and offline). The queues are partially observable as only the number of offline customers is known. Assuming no transitions between two channels, we investigate the individual consumer’s decision whether to queue or not, under FCFS priority policy. We find neither fully observable system nor partially observable system dominates in revenue or social welfare.

■ SC16

CC- Room 304

Operations Strategy in Online Marketplace

Sponsored: Manufacturing & Service Oper. Mgmt/Service Operations

Sponsored Session

Chair: Ruomeng Cui, Emory University, Decatur, GA, 30033, United States

1 - Evolution of Ride Services

Daehoon Noh, University of Maryland, College Park, MD, 20740, United States, nobe301@rhsmith.umd.edu, Tunay Tunca, Yi Xu

Ride services bring together drivers and customers in two-sided matching markets. As these services mature multiple competing operational models emerge. In this paper, we utilize a multi-stage multi-firm model to analyze the competition between different ride service models. We identify the factors that determine pricing and shaping of market segmentation.

2 - Moderation in Pursuit of Truth: Prescriptions for News Publishers and Social Media Platforms

Senthil Veeraraghavan, University of Pennsylvania, Wharton School OPIM Department, 545 3730 Walnut Street, Philadelphia, PA, 19104, United States, senthilv@wharton.upenn.edu, Jiding Zhang, Ken Moon

In this paper, using social media data, we design prescriptions for both news publishers and social media platforms, aiming at controlling the fake news from spreading. We compare multiple potential policies: limiting supply for each source, and encouraging readers to flag fake news. Our paper sheds lights on the effective operational process and steps in managing dynamics of online content.

3 - Estimating and Optimizing the Impact of Photo Assortment in Sharing Economy

Hanwei Li, Massachusetts Institute of Technology, Cambridge, MA, 02139, United States, hanweili@mit.edu, David Simchi-Levi, Michelle Wu, Weiming Zhu

Using data from a leading home-rental platform, we investigate the impact of photo quality and photo assortment on apartment and platform revenue. In particular, we employ Convolutional Neural Network to obtain the quality and the context of each photo posted by apartment owners. Exploiting the unique data structure, we develop a pairwise rank-based choice model to consistently estimate customer preferences over listing characteristics such as price, photo quality and photo assortment. We further conduct counterfactual analysis to study the implication of the optimal assortment strategy on apartment and platform revenue.

4 - Wholesale Price Discrimination in Global Sourcing

Jingyun Li, California State University Stanislaus, Stanislaus, CA, United States, jli9@csustan.edu, Ruomeng Cui, Meng Li, Lili Yu

There is limited study on suppliers’ pricing behaviors in B2B markets. In this research, we study wholesale price discrimination by collaborating with a global trading company which runs a field experiment on a global sourcing marketplace. We find no difference in the wholesale prices quoted to buyers selling in US and South African markets. We also find that suppliers quote higher wholesale prices to White buyers than to Asian and Black buyers regardless of country. Price discrimination disappears when buyers present market information to suppliers, whereas social information can reduce price quotes for only Black and White buyers, but not for Asian (particularly Chinese) buyers.

■ SC17

CC- Room 305

Joint Session MSOM/SERV OP/Practice Curated: Optimization Questions in Ridesharing

Sponsored: Manufacturing & Service Oper. Mgmt/Service Operations

Sponsored Session

Chair: Arash Asadpour, New York University, New York, NY, 10012, United States

1 - Maximum Weight Online Matching with Deadlines

Amin Saberi, Stanford University, San Francisco, CA, 94105, United States, saberi@stanford.edu

We study the problem of matching agents who arrive at a marketplace over time and leave after d time periods. Agents can only be matched while they are present in the marketplace. Each pair of agents can yield a different match value, and the planner’s goal is to maximize the total value over a finite time horizon. First we study the case in which vertices arrive in an adversarial order. We provide a randomized 0.25-competitive algorithm building on a result by Feldman et al.

(2009) and Lehman et al. (2006). When the arrival order is chosen uniformly at random, we show that a batching algorithm, which computes a maximum-weighted matching every (d+1) periods, is 0.279-competitive.

2 - Overcoming Inefficiencies of Dynamic Pricing in Spatial Settings

Daniel Freund, Lyft/MIT, Cambridge, MA, 14850, United States, df365@cornell.edu, Garrett J. van Ryzin

Dynamic (surge) pricing is a frequently used tool to match supply and demand in the gig economy. The comparatively fast-paced dynamics of supply and demand have also led to dynamic pricing featuring prominently in the recent operations research literature.

3 - Designing an Autonomous Rideshare Network

Chinmoy Dutta, Research Scientist, Lyft, San Francisco, CA, 94040, United States, cdutta@lyft.com

We consider the network design problem for an autonomous rideshare service. The objective is to maximize the utilization of the autonomous fleet, given the ride demand flow. We provide a mathematical modeling for the problem and evaluate the effectiveness of the proposed approach.

4 - Batching Policies in Ridesharing Matching

Arash Asadpour, Lyft Inc., Stern School of Business, Kaufman Management Center, New York, NY, 10012, United States, aasadpour@lyft.com

Matching passengers with drivers is an essential part of ridesharing platforms. We study the effect of spatial patterns of demand on the efficiency of various matching policies. In particular, we investigate how the performance of batching policies are affected by such patterns. We will use optimal offline and online policies as the benchmark.

■ SC18

CC- Room 306

Operations in the Digital Era of Industry 4.0

Sponsored: Manufacturing & Service Oper. Mgmt/Supply Chain Sponsored Session

Chair: Cuihong Li, University of Connecticut, Storrs, CT, 06269, United States

Co-Chair: Brian Tomlin, Tuck School of Business, Hanover, NH, United States

1 - Predicting Human Discretion to Adjust Algorithmic Prescription: A Large-scale Field Experiment in Warehouse Operations

Jiankun Sun, Imperial College London, London, 60201, United Kingdom, Dennis Zhang, Haoyuan Hu, Jan A. Van Mieghem

Conventional optimization algorithms focus on efficiency yet tend to overlook human behavioral deviations. We identify such behavioral deviations in the packing process, and propose a new algorithm that predicts discretionary behavior using machine learning to pro-actively adjust the algorithmic prescription. In our randomized field experiment at Alibaba Group, we find that our new algorithm reduces the deviation probability of workers and their average packing time of targeted packages (i.e. packages for which workers are more likely to deviate). This idea of incorporating human deviation to improve optimization algorithms could also be generalized to other processes in logistics.

2 - Blockchain Adoption for Traceability in Food Supply Chain Networks

Puping Jiang, Washington University in St. Louis, Washington University Olin Business School, St. Louis, MO, 63130-4899, United States, jiang.p@wustl.edu, Lingxiu Dong, Fasheng Xu

Innovative retailers in food supply chains have been exploring the use of blockchain as a part of ongoing effort of reducing continuing contamination risks and food waste. We investigate how the adoption of blockchain technology can affect incentives of supply chain members and whether and how its anticipated benefits may be realized. We study a three-tier supply chain with multiple top tier (tier-2) suppliers and characterize the equilibrium contractual arrangement and corresponding tier-2's risk-mitigation effort for both the cases with and without blockchain.

3 - Personal Fabrication as an Operational Strategy: Value of Delegating Production to Customer

Nagarajan Sethuraman, UNC Chapel Hill, Chapel Hill, NC, 27514, United States, Ali Kemal Parlakturk, Jayashankar M. Swaminathan

In this paper, we study an operational strategy enabled by 3D printing – Personal Fabrication (PF) – in which a firm focuses on product's design and delegates its production to customers. Using a 2-dimensional personalization model, we characterize the conditions under which, such a strategy benefits the firm. We study the implications of various roadblocks for such a strategy: high production costs of 3D printing, intellectual property concerns, and product liability issues.

4 - IoT Data Ownership and After-sales Service Supply Chain Management

Cuihong Li, University of Connecticut, School of Business, 2100 Hillside Road, Storrs, CT, 06269, United States, cuihong.li@uconn.edu, Brian Tomlin

For uptime-critical assets, the Internet of Things (IoT) enables condition-based maintenance (CBM) through sensor-generated data combined with advanced analytics. Oftentimes, the asset is designed, built, and maintained by one firm (the OEM) but operated by another firm (the user). In this research, we examine the implications of data ownership (i.e., whether data owned by OEM or user) on the provision and adoption of CBM.

■ SC19

CC- Room 307

Joint Session MSOM/SC/Practice Curated: Empirical Research in Supply Chain Using Behavioral Insights

Sponsored: Manufacturing & Service Oper. Mgmt/Supply Chain Sponsored Session

Chair: Ibanez Maria

1 - Global Supply Chain Management: The Effect of Outsourcing Decisions on Auditor Performance

Ashley Palmarozzo, PhD Candidate, Harvard Business School, Boston, MA, United States, apalmarozzo@hbs.edu, Michael Toffel, Jodi Short

To assess the extent to which working conditions at supplier factories meet a brand's standards, many brands require that social audits be conducted of these factories. In doing so, they face a make-buy decision of whether to use in-house auditors, third party auditors, or both. To shed insight on this decision, we use proprietary data from an apparel brand to identify several circumstances under which in-house versus third party auditors (a) conduct more rigorous audits, and (b) better stimulate improvements in working conditions.

2 - Managerial Insight and "Optimal" Algorithms in Supply Chains

Blair Flicker, University of South Carolina, Columbia, SC, 75208, United States, blair.flicker@moore.sc.edu

Stylized models omit many real-world phenomena. By accounting for unmodeled dynamics, human managers can improve decision making. Human newsvendors endowed with superior demand information should improve profits, but experiments reveal costly suboptimal ordering. I propose a human-machine hybrid ordering approach that consistently outperforms either humans or machines operating alone.

3 - Relative Performance Transparency: Effects on Sustainable Choices

Yanchong Zheng, Massachusetts Institute of Technology, Sloan School of Management, Cambridge, MA, 02139, United States, Ryan W. Buell, Shwetha Mariadassou

We study how transparency into the levels and changes of relative sustainability performance affects consumer choices. Our work considers two forms of transparency: process transparency, in which customers receive information about the company's sustainability performance relative to other companies, and customer transparency, in which customers receive information about their own sustainability performance relative to other customers. Through three studies with 7,308 participants, we observe that revealing the levels of relative performance is more motivating for customers in the process transparency domain, whereas revealing relative changes in performance is more motivating for customers in the customer transpa

rency domain. We employ structural equation modeling to identify the underlying mechanisms for these results. We show that levels information is more reflective of objective performance comparison, thus strengthening motivation in the domain of process transparency. In contrast, changes information helps to mitigate self-serving attribution biases in the customer transparency domain, thus playing a more significant role in affecting motivation.

4 - Focusing Provider Attention: an Empirical Examination of Incentives and Feedback in Influenza Vaccinations

Robert Niewoehner, Kenan-Flagler Business School, Chapel Hill, NC, 27516, United States, Bradley R. Staats

The US Center for Disease Control has been trying to improve flu vaccination uptake for years without much effect. Academic efforts trying to drive the demand side (patients seeking vaccines) have shown limited results. There is a lack of research looking into improving the supply side (providers recommending vaccines), despite the knowledge that providers have a strong influence over their patients' decisions. Working with a vaccine management company focused on driving improvement, we explored whether multiple interventions can lead to an increase in flu shots given, in addition to testing for the presence First-Place Loving behavior, Last-Place Aversion, and Goal Gradient behavior.

■ SC20

CC- Room 308

PSOR Best Paper Competition Finalists

Sponsored: Public Sector OR

Sponsored Session

Chair: Elisa Frances Long, UCLA Anderson School of Management, Los Angeles, CA, 90024, United States

Co-Chair: Fernanda Bravo, UCLA Anderson School of Management, Los Angeles, CA, 90024, United States

1 - Show or Tell: What Improves Agent Decision Making in The Mobile Money Industry? – Evidence from a Field Experiment In Tanzania

Jason Acimovic, Penn State University, University Park, PA, 16802, United States, Christopher Dalton Parker, David F. Drake, Karthik Balasubramanian

Two key decisions operations managers must make when designing systems to support their employees are: 1) what guidance to deliver, and 2) what kind of training (if any) to provide. We examine these choices in the context of mobile money platforms. In partnership with a Tanzanian mobile money operator, we perform a randomized controlled trial to examine how differing types of guidance and training impact the agents' inventory management. Agents who are trained in person and receive an explicit recommendation are less likely to stockout of electronic currency during the day.

2 - An Efficient Frontier Approach to Scoring and Ranking Hospital Performance

Daniel Adelman, University of Chicago, Booth School of Business, 5807 South Woodlawn Avenue, Chicago, IL, 60637, United States

The Centers for Medicare and Medicaid Services (CMS) Star Ratings methodology for publicly evaluating hospitals uses a latent variable model that is based on the presumption of a single, but unobservable, hospital-specific quality factor. We show how under this approach, even if hospitals improve along every dimension, they may nonetheless score lower. We develop a new approach that does not exhibit this behavior, yet also has the capability to autonomously adjust weights as measures are added or subtracted over time. Using data we score and rank nearly every hospital in the United States, and demonstrate the extent to which it agrees or disagrees with the existing approach to the CMS Star Ratings.

3 - Tax-induced Inequalities in the Sharing Economy

Yao Cui, Cornell University, Ithaca, NY, 14853, United States, Andrew M. Davis

We use a machine learning method (generalized causal forest) to study the heterogeneous treatment effects of the tax policy on Airbnb. While the tax regulation is intended to alleviate the pressure that Airbnb creates to hotels, we find that it has led to unintended consequences for Airbnb participants. In particular, the tax policy adversely affects residential listings more than commercial listings, and adversely affects those listings whose service offerings are more differentiated from hotels. These distributional impacts indicate that the goal of the tax policy is not effectively achieved. We further provide insights to policy makers and sharing economy platforms regarding tax regulation.

4 - How Many Undocumented Immigrants Are There in the US?

Edward H. Kaplan, Yale University, Yale School of Management, Box 208200, New Haven, CT, 06520-8200, United States, Scott Rodilitz

The number of undocumented immigrants in the US is one of the most controversial quantities at the heart of the US immigration debate. The Mexican Migration Project reports departure dates to and return dates from the United States for undocumented Mexican immigrants sampled in Mexico after their return from the US along with the total number of trips for each household sampled. Such samples can be analyzed using newly developed probability models to obtain new estimates of the number of undocumented immigrants in the US over time. The resulting estimates are much larger than those commonly reported in the media, and are broadly consistent with the findings of Fazel-Zarandi, Feinstein and Kaplan (2018).

■ SC21

CC- Room 309

Crowdfunding

Sponsored: Manufacturing & Service Oper. Mgmt/iFORM

Sponsored Session

Chair: Michael R Wagner, University of Washington, Seattle, WA, 98195, United States

Co-Chair: Soraya Fatehi

1 - Reward-based Crowdfunding Campaigns: Informational Value and Access to Venture Capital

Rachel Rong Chen, University of California-Davis, One Shields Avenue, Davis, CA, 95616, United States, rachen@ucdavis.edu, Paolo Roma, Esther Gal-Or

We consider an entrepreneur who designs a reward-based crowdfunding campaign when the campaign provides a signal about the future demand for the product and subsequent Venture Capital (VC) is needed. We find that both the informativeness of the campaign and considerations related to gaining access to VC funding affect the entrepreneur's choice of campaign instruments, as well as her decision of whether to run a campaign. As the use of crowdfunding platforms becomes more prevalent for entrepreneurial projects, our study offers a deeper understanding on the dual role of reward-based crowdfunding in terms of acquiring demand information and raising capital for early-stage startups.

2 - Choosing the Right Campaign Mode in Reward-based Crowdfunding

Simone Marinesi, The Wharton School, University of Pennsylvania, Philadelphia, PA, 19103, United States, marinesi@wharton.upenn.edu, Ekaterina Astashkina, Karan Girotra

We compare the two most popular forms of crowdfunding campaign, All-or-Nothing (AoN) and Flexible Funding (FF). The existing literature considers FF Pareto dominated by AoN, but FF is widely used in practice. Our model attempts to reconcile this discrepancy by showing that FF campaigns can outperform AoN camapaigns for certain type of crowdfunding projects.

3 - Crowdfunding via Revenue-sharing Contracts

Soraya Fatehi, University of Washington, Michael G. Foster School of Business, Seattle, WA, 98195-3200, United States, sfatehi@uw.edu, Michael R. Wagner

One of the newest versions of crowdfunding allows a firm to raise capital from a crowd of investors and repay them a multiple of their investment by sharing a percentage of its future revenue, under a revenue-sharing contract. This means that investors will receive M>1 dollars for every dollar that they have invested over an investment horizon of uncertain duration. This contract, as a flexible repayment agreement, is linked with the financial performance of the firm, allowing variable payments and investment horizons. We show that revenue-sharing contracts align firms' and investors' incentives in a way that was not possible with traditional contracts.

■ SC22

CC- Room 310

Agricultural/Food Supply Chains

Sponsored: Manufacturing & Service Oper. Mgmt/Sustainable Operations

Sponsored Session

Chair: Karthik Murali, University of Alabama, Tuscaloosa, Tuscaloosa, AL, 35487, United States

Co-Chair: Isil Alev, Boston College, Chestnut Hill, MA, 02467, United States

1 - Optimal Investment of Farming Mechanization in Rainfed Agriculture

Ying (Maggie) Zhang, Clemson University, Clemson, SC, United States, ying6@clemson.edu, Jayashankar M. Swaminathan

We study the procurement of seeds and farm equipment for a single crop in a multi-period planting horizon under budget constraint. The optimal procurement decision is made before the start of the horizon to maximize the final yield and the subsequent planting decisions are optimized. We show that under fixed budget, the optimal planting capacity is generally increasing under favorable planting conditions such as higher soil moisture level, higher seed quality and favorable climate conditions. In the computational study, we utilized field weather data in Southern Africa to explore the impact of machine cost and farm size on the optimal machine capacity.

2 - Assessing Post-harvest Losses under Vertical Coordination - Evidence from an Emerging Economy

Alwin Dsouza, PhD Candidate, Arizona State University, Mesa, AZ, United States, adsouza3@asu.edu, Ashok Mishra, Scott Webster

Post-harvest losses (PHL) in developing countries amount to 30-40 percent. Lack of proper transportation and marketing facilities along with failures to comply with minimum standards are the main reasons for high PHL. This study analyzes the links between contract farming (CF) (production (PC) and marketing contracts (MC)) and PHL. Using survey data from India on okra farming (highly perishable produce), we conclude that PC and MC growers have higher profits along with higher PHL compared to IF growers. Furthermore, we find that if the quantity rejected due to non-compliance to minimum standards is lowered, PC and MC growers make higher profits with lower PHL.

3 - Irrigation Management under Temporal and Spatial Variability

Erkut Sonmez, University of Nebraska-Lincoln, Lincoln, NE, United States, drerkutsonmez@gmail.com, Baris Ata, Derek Heeren

Several studies reported that agricultural production must at least double in the near future to supply rapidly growing world population and food demand. Irrigation is one of the main methods to improve agricultural productivity. Fresh water scarcity, increasing costs, and climate changes urge for sustainable and efficient methods for irrigation which accounts for 70 percent of global fresh water usage. In this paper, we study dynamic irrigation management considering temporal and spatial variability in relevant environmental and field properties.

4 - Too Good to Eat? Cosmetic Standards and Waste in Agricultural Supply Chains

Pascale Crama, Singapore Management University, 50 Stamford Road, Singapore, 178899, Singapore, pcrama@smu.edu.sg, Yangfang Zhou, Jiahui Xu

Agricultural waste starts at the farm, with a portion of the harvest discarded due to cosmetic standards set by the downstream retailers. We examine the supply chain interactions that cause downstream retailers to set high cosmetic standards in the face of customers who have prefer 'beautiful' food.

■ SC23

CC- Room 3A

Decision Analysis Practice Award Competition

Sponsored: Decision Analysis

Sponsored Session

Chair: Michael C. Runge, USGS Patuxent Wildlife Research Center, Laurel, MD, 20708, United States

1 - Operations Research Improves Biomanufacturing Efficiency at Merck Sharp & Dohme

Yesim Koca, Eindhoven University of Technology, Eindhoven, Netherlands, y.koca@tue.nl, Tugce Martagan, Ivo Adan, Bram van Ravenstein, Marc Baaijens, Oscar Repping

Production and planning decisions in biomanufacturing are often challenging owing to batch to batch variability and uncertainty in the production yield and quality. To improve biomanufacturing efficiency, a multidisciplinary team of researchers collaborated over three years to develop a portfolio of decision support tools. These tools comprise optimization models, and provide a data-driven, operations research based approach to reduce biomanufacturing costs and lead times.

2 - Decision Tools for Biodiversity: A Breakthrough for Ecological Outcomes in Fire Management

Josephine MacHunter, Arthur Rylah Institute for Environmental Research, Heidelberg, Australia, Josephine.MacHunter@delwp.vic.gov.au, Libby Rumpff, Tracey Regan, Nevil Amos

Making decisions about fire management in Victoria, Australia requires difficult trade-offs to protect human life, property and biodiversity. However, evaluating and integrating the complex suite of risks to ecological values has been challenging. Working with government across multiple fire management regions, we applied multi-criteria decision making using a participatory process to develop a decision framework. The framework includes a user-friendly analysis module to enable faithful, transparent and rapid values-focused consideration of ecological values in fire management.

3 - Decision Analysis Meets Sustainable Planning in Québec City: The Case of Multicriteria Decision Aiding and Complete Streets

Francis Marleau Donais, Université Laval, Québec City, QC, Canada, francis.marleau-donais.1@ulaval.ca, Irene Abi-Zeid, E. Owen Waygood, Roxane Lavoie

Decision-making processes in transportation projects do not always explicitly take into account sustainability dimensions and often neglect aspects from fields other than engineering, such as environment and public health. Using multicriteria decision analysis, we structured and developed a new decision-making process for street redesign in Québec City. The objective was to identify the higher priority streets that should be redesigned as Complete Streets. The results were integrated in a spatial decision support system that has become an essential operational tool in use since 2017.

■ SC24

CC- Room 3B

Preference-driven Decision Aiding

Sponsored: Multiple Criteria Decision Making

Sponsored Session

Chair: Roman Slowinski, Poznan University of Technology, Poland

Co-Chair: Adiel de Almeida Filho, Brazil

1 - Post Consensus Analysis of Group Decision Making Processes by Means of a Graph Theoretic and Association Rules Approach

Evangelos Triantaphyllou, Louisiana State University, Division of Computer Science & Engineering, Baton Rouge, LA, 70803, United States, etriantaphyllou@yahoo.com, Juri Yanase

It is assumed that a group of experts evaluates a finite set of alternatives as part of a group decision making (GDM) process. The GDM process may go through a number of iterations. The experts use their personal preferences to make decisions. The process ends when a consensus has been reached or no expert is willing to alter his/her ranking. The GDM process may function for some time under the same or slightly changing group of experts. It is assumed that logs are kept of the sessions. An approach based on graph theory and the mining of association rules is proposed to analyze the data generated from such logs. Such analysis may reveal some potentially very useful information on the way the experts make decisions.

2 - Dominance-based Rough Set Approach to Revealing Patterns of Auto Loan Frauds

Adiel de Almeida Filho, Universidade Federal de Pernambuco, Recife, Brazil, adielfilho@cin.ufpe.br, Jerzy Błaszczy ski, Anna Matuszyk, Anna Matuszyk, Marcin Szel g, Roman Slowinski

Auto loan is a significant financial product not yet explored in the literature, unlike the misuse of credit cards, for instance. Given the recent increase in fraudulent transactions concerning auto loan applications, this work tests a new data set for auto loan applications using a technique not yet explored for financial fraud prediction, namely the Dominance-based Rough Set Balanced Rule Ensemble (DRSA-BRE).

3 - Preference-driven Cone Contraction Algorithms for Evolutionary Multiple-objective Optimization

Roman Slowinski, PhD, Professor, Poznan University of Technology, Poznan, 60-965, Poland, roman.slowinski@cs.put.poznan.pl, Milosz Kadzinski, Michal Tomczyk

We present a family of interactive evolutionary algorithms for multiple-objective optimization. In the phase of preference elicitation, a Decision Maker (DM) is asked to compare some pairs of solutions from the current population. Such holistic information is represented by a set of compatible instances of achievement scalarizing functions which contribute to the construction of preference cones in the objective space. These cones are systematically contracted during the evolutionary search, because an incremental specification of the DM's pairwise comparisons is progressively reducing the DM's most preferred region in the objective space.

4 - A Preference-driven Clustering Model for Multiple Criteria Decision Aiding with Mixed Evaluations

Sarah Ben Amor, University of Ottawa, 55 Laurier East (7123), Ottawa, ON, K1N 6N5, Canada, benamor@telfer.uottawa.ca, Ahmet Kandakoglu

In the context of preference driven decision-aiding, we address the problem of ordered clustering based on the multiple criteria aggregation procedure, MCAP-mix designed for mixed evaluations to deal with different types of information imperfections. The distances between preference relations generated for each pair of alternatives by MCAP-mix are used as a measure of closeness of the alternatives. Based on these distances, an extension of the K-medoids clustering algorithm is developed through an Integer Programming (IP) formulation to partition the set of alternatives into ordered clusters. A case study is provided to illustrate the proposed model.

■ SC25

CC- Room 401

Marketing Operations Interface II

Emerging Topic: Interface of Marketing & Operations&# ;

Emerging Topic Session

Chair: Baojun Jiang, Washington University in St. Louis, St. Louis, MO, 63130, United States

Co-Chair: Wen Diao, Fudan University, Shanghai, China

1 - Consumer Fairness Concerns and Dynamic Pricing in a Channel

Wen Diao, Fudan University, Fudan University, Shanghai, China, Mushegh Harutyunyan, Baojun Jiang

This paper studies the dynamic pricing decisions in a channel where there is a segment of consumers who have fairness concerns about retail price increases. We show that, in a market with growing demand, the presence of consumers with fairness concerns can in equilibrium reduce both the first-period and second-period retail prices, resulting in an all-win situation for the manufacturer, the retailer, and the consumers.

2 - Implications of Product Substitutability in a Common Retailer Channel

Honggang Hu, University of Florida, Gainesville, FL, United States, Quan Zheng, Xiajun Amy Pan

We study the effect of product substitutability on firms' profits in a common retailer channel. Specifically, we analyze whether the retailer and manufacturers prefer more or less substitutability for settings with different demand functions, number of manufacturers, and bargaining powers between manufacturers and the retailer.

3 - Strategic Effects of Equity Ownership in Decentralized Channels

Baojun Jiang, Washington University in St. Louis, Olin Business School, St. Louis, MO, 63130, United States, baojunjiang@wustl.edu, Wen Diao, Yifan Xu

This paper develops an analytical framework to examine the strategic and economic impact of equity ownership in vertical relationships. We show that partial ownership can be an all-win situation for the manufacturer, the retailers and the consumers.

4 - Referral and Learning on Social Networks: Implications for Newsvendor

Guangwen Kong, University of Minnesota, Minneapolis, MN, 55414, United States, gkong@umn.edu, Ankur Mani, Yuanchen Su

We examine the impact of social learning in a referral program when customers' preferences are correlated. We characterize customers purchasing strategies based on their information and their types, and derive the demand distributions when customers are involved in social learning in a referral program. We identify the bias and variance trade-offs in the demand distribution and investigate the firm's inventory decision in a referral program. We find that the stock-out of one product influences the demand of the other product when customers are involved in social learning. The optimal design of a referral program generates market exposure with a moderate increase in inventory cost.

■ SC26

CC- Room 4C-1

Best Service Science Paper II

Sponsored: Service Science

Sponsored Session

Chair: Ming-Hui Huang, National Taiwan University, Taipei, 10617, Taiwan

1 - How Price Dispersion Changes When Upgrades are Introduced: Theory and Empirical Evidence from the Airline Industry

Yao Cui, Cornell University, Ithaca, NY, United States, yao.cui@cornell.edu, A. Yesim Orhun, Izak Duenyas

We study the effect of introducing a new vertical differentiation strategy, paying for an upgrade to a premium product, on the price dispersion of the base product arising from existing price discrimination strategies. We first provide a theoretical analysis that highlights two competing pressures that the new upgrades will create on the price discrimination of the base product. We then conduct an empirical analysis based on a proprietary transaction-level data set from a major U.S. airline company who introduced the option to upgrade to a new type of premium economy seating within the coach cabin. Finally, we discuss implications of our results for firm revenues and consumer welfare.

2 - Dynamic Pricing for Heterogeneous Time-Sensitive Customers

Ramandeep Randhawa, University of Southern California, Los Angeles, CA, 90089, United States, ramandeep.randhawa@marshall.usc.edu, Negin Golrezaei, Hamid Nazerzadeh

A core problem in the area of revenue management is pricing goods in the presence of strategic customers. We study this problem when customers are heterogeneous with respect to their initial valuations for the item and their time sensitivities, i.e., the customers differ in both their initial valuations and the rates at which their initial valuation decreases with delay in purchase. We characterize the optimal mechanism for selling durable goods in such environments and show that delayed allocation and dynamic pricing can be effective screening tools for maximizing firm profit. We also investigate the impact of production and holding costs on the optimal mechanism.

3 - Intertemporal Price Discrimination via Randomized Pricing

Jiahua Wu, Imperial College Business School, Imperial College London, London, SW7 2AZ, United Kingdom, Hongqiao Chen, Ming Hu

Firms adopt dynamic pricing in a wide range of industries. The undesirable, but inevitable, consequence is that consumers are trained to time their purchases strategically. In this paper, we study randomized pricing, where the firm randomly varies prices over time, to counteract consumers' strategic behavior. The firm pre-commits to a price distribution ex ante, and in each period, a price is randomly drawn from the chosen distribution. We characterize the optimal price distribution and compare its performance against deterministic pricing policies, including static pricing and cyclic deterministic pricing policies.

4 - To Brush or Not to Brush: Product Rankings, Customer Search, and Fake Orders

Chen Jin, Assistant Professor, National University of Singapore, Singapore, Luyi Yang, Kartik Hosanagar

"Brushing"-the practice of online merchants placing fake orders of their own products to artificially inflate sales on e-commerce platform-has recently received widespread public attention. On one hand, brushing enables merchants to boost their rankings in search results, because products with higher sales volume are often ranked higher. On the other hand, rankings matter because search frictions faced by customers narrow their attention to only the few products that show up at the top. Thus, fake orders from brushing may affect customer choice. We build a stylized model to understand merchants' strategic brushing behavior and its welfare implications.

5 - Scan-based Trading and Bargaining Power: A Structural Model of Vertical Retail Supply Relationships

Stanley Lim, University of San Diego, San Diego, CA, United States, stanleylim@sandiego.edu, Timothy Richards, Elliot Rabinovich, Min Choi

Using a Nash-in-Nash bargaining model, panel data, and structural econometrics, we examine how the adoption of scan-based trading (SBT) contract relative to vendor managed inventory (VMI) contract influence retailer-supplier bargaining power in a vertical relationship. We find that both retailer bargaining power and inventory shrink are higher under SBT than VMI contracts. Through a series of counterfactual simulations, our results show that a switch from a VMI to an SBT contract arrangement generates an increase of about 46% in bargaining power for retailers, allowing these firms to extract a higher share of the total margin in their vertical relationships with the supplier.

■ SC27

CC- Room 4C-2

Service Operation

Contributed Session

Chair: Jie Yang, Texas A&M University

1 - Bottleneck Analysis in Multistage Service Systems

Xiaofeng Zhao, University of Mary Washington, Fredericksburg, VA, United States, xzhao@umw.edu

The bottleneck is the key ingredient for improving the performance of the service systems. This research combines results on multiclass queuing networks and proposes approximations for the bottleneck analysis in service operations. The inter-arrival times of the arrival processes and the service times are generally distributed. The analysis is based on the method of decomposition where the entire network is broken up into subsystems which can be analyzed individually by assuming renewal arrival and departure processes.

2 - Analyzing Internal Barriers and Their Causal Relationship of Servitization of Automobile Industry Using Grey-DEMATEL Approach

Bibekananda Mishra, Research Scholar, Indian Institute of Technology-Kharagpur, Kharagpur, India, Biswajit Mahanty, Jitesh J. Thakkar

Adoption of servitization in manufacturing sector has attracted attention from the international researchers and practitioners recently. Though some manufacturing firms increased their revenue generation through servitization, still the topic is at its nascent stage striving hard for implementation. In this research we analyse the internal barriers and drivers of servitization strategies by employing Grey Decision Making Trial and Evaluation Laboratory (DEMATEL) approach for automobile industry. This research uncovers the Critical Success Factors and their causal relationships for effective adoption of servitization initiatives in the automobile service sectors.

3 - Digital Transformation in Retail Banking and the Role of Digital Service Development

Ting Cao, York University, Toronto, ON, Canada, tingc0109@gmail.com, Murat Kristal, Larry Menor

We empirically examine the impact of digital transformation on digital service performance in retail banking. A multi-dimensional construct, digital service development, is developed to capture banks' efforts in generating digital service options through the integration of digital technologies into the operational system. A two-stage approach is used for new multi-item scale development. A global based survey "Innovation in Digital Services" is conducted to collect data. The results offer not only "know-what" of digitalization but also the "know-how" of developing digital services by appropriately managing relevant perspectives to achieve higher digital service performance.

4 - Auctions in Staffing for Self-scheduling Service

Jie Yang, Texas A&M University, College Station, TX, United States, nemoyj1989@tamu.edu

This research examines an auction mechanism in managing staff capacity for sharing economy such as ride-sharing services and work-from-home call centers. The firm has two types of potential employees: type 1 staff is hired long before the work shift begins and type 2 is hired just before the start of the shift. We analyze the short-term scheduling and long-term planning of managing staff capacity jointly. The objective of this research is to provide insights to staff managers on whether and under which conditions auction can outperform the common fixed wage model.

5 - Optimizing Resource Allocation in Service Industries under the Effect of Learning and Forgetting

Hamid Afshari, University of British Columbia, Kelowna, BC, Canada, afsharih@myumanitoba.ca

Learning by repeating reduces the task completion time in production, while interruptions such as long work breaks could result in forgetting and longer completion time. There is a lack of research on the effects of learning and forgetting on service industries. This paper contributes to the literature by introducing a novel mathematical model to evaluate such effects and optimize resource allocation. Valuable results are expected when the model is implemented in safety and cost-sensitive services such as health care and maintenance projects as validated un a safety watch service industry.

6- Auctions in Staffing for Self-scheduling Service

Matthew F. Keblis, Yanling Chang

This research examines an auction mechanism in managing staff capacity for sharing economy such as ride-sharing services and work-from-home call centers. The firm has two types of potential employees: type 1 staff is hired long before the work shift begins and type 2 is hired just before the start of the shift. We analyze the short-term scheduling and long-term planning of managing staff capacity jointly. The objective of this research is to provide insights to staff managers on whether and under which conditions auction can outperform the common fixed wage model.

■ SC28

CC- Room 4C-3

Operations-marketing Interface Models

Sponsored: Service Science

Sponsored Session

Chair: Muge Yayla-Kullu, PhD, University of Central Florida, FL, United States

1 - The Interplay Between Perceived Quality and Resource Utilization: Does Product Size Matter?

Muge Yayla Kullu, University of Central Florida, Orlando, FL, 32816, United States, muge@ucf.edu, Dongling Huang, Praowpan Tansitpong

We empirically investigate how customer perceived quality and resource consumption differences of products may impact a firm's product line decisions, and how they relate to its success in the marketplace. Using an international airline data set, we find that an indirect effect of quality differentiation exists through resource allocation decisions of the firm. We confirm a positive relationship between the premium product focus and the market share. We also show that an increase in resource consumption levels has a negative impact on the allocation towards the premium segment and the overall performance therein.

2 - Effective Algorithms for Lead Time Quotation with Contingent Orders

Ana Muriel, University of Massachusetts, Dept of Mechanical & Industrial Engineering, Amherst, MA, 01003, United States, muriel@ecs.umass.edu, Ron Mallach

Make-to-Order (MTO) firms experience sparse and difficult-to-predict demand generated through the completion of successful project bids with potential customers. Demand is considered contingent until the bid is either accepted or declined by the customer and is reliant on competitive pricing and lead times. Due to uncertainty in the outcome of these customer decisions, firms may hedge against the possibility of losing project bids by bidding multiple projects requiring competing capacities. In this paper, we present simulation-based algorithms to accurately estimate lead time quotations for project bids, considering capacity-competing, contingent backlogs.

3 - Which Stage of the Industry Lifecycle Do Clinical Research Organizations Currently Reside in? An Exploratory Analysis Using Clinical Trials Data

Lidia Betcheva, University of Cambridge, Trumpington Street, Cambridge, CB2 1AG, United Kingdom, lb702@jbs.cam.ac.uk, Feryal Erhun

Analysts have offered various outlooks regarding the future of the clinical research organization (CRO) industry. Applying Bass diffusion methodology on an extensive dataset assembled from the AACT (Aggregate Analysis of ClinicalTrials.gov) database and other publicly available data, we aim to answer the following: Which stage of the industry lifecycle do CROs currently reside in? We further study the dynamics of CRO adoption. Our results carry important capacity and capability planning implications for CRO managers.

4 - Optimal Product Design Strategies with Critical Components and Brand Value Consideration

Kunpeng Li, California State University,Northridge, CA, 84332, United States, Dilip Chhajed, Suman Mallik

Critical components in a product determine the product performance and user experience. Critical components also have brand value, which directly affects consumer demand and the manufacturer's profit. Companies vary considerably in terms of how they implement critical components into their products. This paper aims to investigate how a manufacturer chooses its optimal product design strategy regarding critical component integration and how consumer brand preference affects this optimal strategy.

5 - On Rational Inattention and Product Variety

Tugce Vural, Smeal College of Business, State College, PA, United States, Aydin Alptekinoglu

We develop a choice model based on the theory of rational inattention and apply it to a retail format. By analyzing this model, we study the economics of the retailer's assortment decision when customers are assumed to be rationally inattentive.

■ SC29

CC- Room 4C-4

Mechanism Design for Social Good

Sponsored: Auction and Market Design

Sponsored Session

Chair: Irene Yuan Lo, Palo Alto, CA, 94306, United States

1 - Group-fairness in Influence Maximization

Bryan Wilder, University of Southern California, Los Angeles, CA, 90016, United States, bryan.wilder0@gmail.com, Alan Tsang, Eric Rice, Milind Tambe, Yair Zick

Influence maximization is a widely used model for information dissemination in social networks in many socially important domains. A critical question is whether the benefits of such interventions are fairly distributed across different groups in the population; e.g., avoiding discrimination with respect to sensitive attributes such as race or gender. We introduce formal definitions of fairness in influence maximization, provide an algorithmic framework to find solutions which satisfy fairness constraints, and conduct experiments on real data from an HIV prevention intervention. In the process, we improve the state of the art for general multi-objective submodular maximization problems.

2 - Fair Division Without Disparate Impact

Christian Kroer, Columbia University, Computer Science Department, 5000 Forbes Avenue, New York, NY, 15213, United States, christian.kroer@columbia.edu, Alex Peysakhovich

We consider the problem of dividing items between individuals in a way that is fair, both in the sense of distributional fairness and in the sense of not having disparate impact across protected classes. We study the setting where allocations must be similar across protected classes, as measured by some objective. We introduce two variants of the standard CEEI mechanism: equitable equilibrium from equal incomes, which removes disparate impact in allocations, and competitive equilibrium from equitable incomes, which removes disparate impact in attained utility levels. We experimentally evaluate the tradeoffs between efficiency, equity, and disparate impact in a recommender-system market.

3 - Pay-for-quality or Pay-for-selection? Evidence of Reverse Cross Subsidization in Healthcare

Zhaowei She, Georgia Institute of Technology, Atlanta, GA, 30067, United States, zhaowei@gatech.edu, Turgay Ayer, Bilal Gokpinar

Risk-adjusted capitation payment models have been increasingly adopted by payers in the U.S. healthcare market during the past decade. However, early study shows that Medicare Advantage (MA), the largest capitation program in the U.S., has been suffering from the risk selection problem, where the payer (CMS) systematically over and under reimburses certain patient subgroups. This paper provides patient-level evidence on how risk selection is conducted in MA, and empirically shows that risk selection problem cannot be eliminated by pure statistical risk adjustment designs.

4 - Simple and Optimal Contract Design for Environmental Conservation

Wanyi Li, Stanford University, Stanford, CA, United States, wanyili@stanford.edu, Itai Ashlagi, Irene Yuan Lo

We consider the problem faced by a budget-constrained principal whose goal is to maximize conservation of environmental resources that are owned by agents, given that consumption is irreversible. We show that the optimal contract in this setting has a simple structure in terms of budget allocation and menu selection over time. The findings have implications for "Payment for Ecosystem Services" where governments and NGOs pay private-land-owners to not deforest or to reduce pollution.

■ SC29a

CC- Room 400

Supply Chain Management IV

Contributed Session

Chair: Bosung Kim, Sauder School of Business, Vancouver, BC, Canada

1 - Direct Selling by Supplier Improves System-wide Information Flow

Zhongyuan Hao, Dongbei University of Finance and Economics, Dalian, China, lingyuran881201@163.com, Li Jiang

Consider a bilateral monopoly selling to a market with uncertain demand. The retailer has access to a demand signal. The supplier can add a direct channel, which grants it market access as well. The supplier and the retailer can acquire signals from each other with payments. We study the effects of direct selling by the supplier on the information flow in the system. We find that direct selling by the supplier has a fundamental impact on information flow. While no information flow is sustainable when the supplier stays with retailing, add-on direct selling incentivizes it to share the signal from market access with the retailer for free and acquire the retailer's signal as well.

2 - Online vs. Offline: How Should a Supplier Encroach on its Retailer with Traffic Consideration?

Jie Zhang, Guangdong University of Finance and Economics, Guangzhou, China, jiezh@gdufe.edu.cn

It is increasingly common for suppliers to encroach on its retailer with an online/offline direct channel. While direct channel management has been studied thoroughly in the literature, the effect of traffic congestion is often ignored. In this paper, we investigate a supplier's decision on whether and how to encroach by considering the traffic congestion cost. We analyze the equilibrium strategies and identify the supplier's channel preference under various conditions, and show that traffic congestion indeed reduces the supplier's incentive of encroachment.

3 - Long-term Collaboration in High-tech Manufacturing

Mirjam S. Meijer, Eindhoven University of Technology, Eindhoven, Netherlands, m.s.meijer@tue.nl, Ton de Kok, Willem van Jaarsveld

In high-tech manufacturing, shortage of a single component can lead to extremely costly delivery delays. To avoid such shortages a manufacturer tries to incentivize his suppliers to create sufficient capacity, which is not easy because overcapacity is costly. Therefore, we observe long-term relationships between a manufacturer and his suppliers. We model this relation as a repeated Stackelberg game in which the manufacturer is the natural leader. After each period, the manufacturer decides on her supplier for the next product generation. We compare the case in which supplier-performance is taken into account to the case where it is not and evaluate the effect on individual and supply chain profits.

4 - Collaborative Supply Chain Network Design with Overlapping Coalitions

Reza Alikhani, Postdoctoral Researcher, EM Normandie Business School, Le Havre, France, Alikhani64@gmail.com, Yann Bouchery, Benjamin Legros

In this study, we consider a collaborative network design with coalition formation. The model determines the optimal number of coalitions for a carrier as well as the number of players for each coalition. In addition, we consider the possibility of joining overlapping coalitions in which a carrier can join more than one coalition. We examine numerous instances to show the applicability of the model.

5 - Research on Supplier Relationship Management of Large Complex Equipment Enterprises

Xinyu Ma, Nanjing University of Aeronautics and Astronautics, Nanjing, China, mxywhispers@nuaa.edu.cn, Qing Zhang, Wei Zhang

Selecting suitable model of SRM is vital to improve enterprises' production efficiency and decrease costs. The article firstly classifies enterprise's suppliers using ABC classification and establishes evaluation model for suppliers marked as A and B by applying BSC and KPI to indicators construction. After determining index weight using AHP, grey clustering coefficients to judge suppliers can be calculated. Afterwards the supplier-manufacturer relationship can be divided into separate partnership through Maslow theory and existing results. The actual and should-be stage of cooperation are estimated by the output result, we can then conclude specific actions to strengthen cooperation.

6 - Sourcing Decision in the Presence of a Complementary Component

Bosung Kim, Pusan National University, Busan, Korea, Republic of, Jeongeun Sim

This paper examines the manufacturer's component sourcing decision in the presence of a complementary component. While there have been extensive studies on manufacturer's make-or-buy decisions, the impact of a complementary component on the decision has been largely ignored in the literature despite the fact that most products have multiple key components provided by different suppliers. We construct a game theoretical model between a manufacturer and a supplier (or suppliers), and compare the manufacturer's profit under the three sourcing regimes.

■ SC30

CC- Room 6A

Tutorial: Field Experiments in Operations Management

Emerging Topic: Tutorials

Emerging Topic Session

1 - Tutorial - Field Experiments in Operations Management

Bradley R. Staats, University of North Carolina at Chapel Hill, Chapel Hill, NC, 27599-3490, United States, Maria R. Ibanez

Field experiments are controlled interventions in the real world that enable researchers to measure the effects of a treatment on a randomly assigned subset of subjects. In this paper, we review the advantages and disadvantages of field experiments and provide some practical prescriptions to attain and evaluate a field experiment's relevance—in other words, the theoretical implications of understanding the effects of the treatment— and rigor, based on many methodological considerations.

■ SC31

CC- Room 6B

Networks and Human Resources

Sponsored: Military and Security

Sponsored Session

Chair: Lee Evans, PhD, United States Military Academy

1 - Economic Growth and U.S. Troop Deployments in Kuwait

Robert Lasater, US Army, West Point, NY, United States

Disentangling the direct effects of US troops on economic growth from indirect effects of conflict resolution and stability on growth is an empirical challenge. This paper provides new evidence on the economic impact of troop deployments by studying Kuwait in early period of the Iraq War. Utilizing synthetic control matching, this paper estimates the effects of an exogenous increase of security from a large deployment of US troops without the destruction of conflict and finds an increase in economic growth. I explore mechanisms for growth, finding evidence for the growth caused by the security umbrella, lesser by expenditures, and limited evidence for effects of diffusion.

2 - Time-staged Network Flow Modeling and Transportation Planning for U.S. Noncombatant Evacuation Operations in South Korea

John Kearby, US Army, West Point, NY, United States, john.a.kearby.mil@mail.mil

We formulate a network model of the South Korean noncombatant evacuation system as a mixed integer linear program to determine an optimal flow configuration that minimizes total evacuation time. The solution considers the capacity and resource constraints of each transportation mode and vehicle routing completes the plan by producing an exact schedule for each individual asset throughout the operation. A case study introduces additional restrictions during mission planning and disrupts the network and fleet during the actual evacuation to demonstrate the usefulness of the complete procedure.

3 - Utilizing Industrial and Systems Engineering Tools to Reduce Healthcare Associated Infections

Jose Jimenez, Assistant Professor, United States Military Academy, West Point, NY, United States, jose.jimenez@westpoint.edu

Healthcare acquired infections (HAIs) have decreased over the last decade. Nevertheless, HAIs are still a burden for healthcare systems. In addition to the increase in morbidity and mortality of patients that are already at risk, HAIs create resource constraints in healthcare facilities. Different solution approaches involve early detection of HAIs using statistical tools, incorporation of special sociotechnical interventions, high performance computer simulation, human factors design, and application of public health practices. Many of the current tools utilized by healthcare facilities were developed through a systems-based, multidisciplinary approach.

4 - Network Flows Applied Modular Classes Within Academic Terms

Daniel Meadows, United States Military Academy, West Point, NY, 10996, United States

A directed network can be created from course concept maps of multiple courses. Academic departments can choose concepts required for specific majors and apply a shortest path algorithm to find the minimum blocks of instruction necessary to cover desired topics. A network flow model can then be used to schedule blocks of instruction and constraints can be written for resource limitations such as number of instructors, hours and classrooms available.

5 - Combining Regression and Mixed-Integer Programming to Model Counterinsurgency

David Galbreath, United States Military Academy, Marvin Lee King, Alexandra M. Newman, Amanda Hering

We develop a mixed-integer program to provide an estimate of the number of forces required to maximize the probability of a favorable resolution to counterinsurgent and host-nation countries engaged in a counterinsurgency, while minimizing unfavorable resolutions and the number of counterinsurgent deaths. This program integrates a multivariate piecewise-linear regression model to estimate the number of counterinsurgent deaths each year and a logistic regression model to estimate the probability of four types of conflict resolution over a fifteen-year time horizon. We use Somalia as a case study to estimate how counterinsurgent strategies affect the probability of the conflict resolution.

6 - Forecasting for the Afghan National Army

Christopher Collins, United States Military Academy, West Point, NY, United States

Given a fiscally austere and tumultuous future strategic environment, the Government of the Islamic Republic of Afghanistan (GIRoA) must maintain an All-Volunteer Army force with sufficient capacity and capability to respond to domestic security threats. The Afghan All-Volunteer Army Model (AAVAM) answers the Commanding General, Combined Security Transition Command-Afghanistan question of what size force the Afghan National Army (ANA) could field in 2021 given the current recruiting and attrition environment. The analytical approach utilizes a heuristic, providing sufficient deterministic modeling where an optimal solution is not guaranteed. Time-series forecasting and regression each provide a data-driven basis for approximating the force size the ANA could field in 2021 under the current operational environment and disparate accession enterprise

■ SC32

CC- Room 6C

Undergraduate Operations Research Prize I

Emerging Topic: Undergraduate Operations Research Prize Emerging Topic Session

Chair: Nan Kong, Purdue University, Biomedical Engineering, West Lafayette, IN, 47906-2032, United States

1 - A Branch-and-Bound Framework for Infinite-horizon Multi-model Markov Decision Processes

Vinayak Ahluwalia, University of Michigan, Glenview, IL, 60026, United States

Markov decision processes (MDPs) are models for sequential decision-making that inform decision making in many fields, including healthcare. However, MDPs are subject to parameter ambiguity because parameters estimated from different data sources may lead to different recommendations. A study of this problem for finite-horizon MDPs succeeded with a branch-and-bound approach, so we extend the study to infinite-horizon MDPs and recommend algorithmic designs that reduce computation time. We use previously-published computational studies to demonstrate our algorithm's effectiveness.

2 - Incorporating Equity into the School Bus Scheduling Problem

Dipayan Banerjee, Northwestern University, Evanston, IL, United States

We consider the school bus scheduling problem (SBSP) which simultaneously determines school bell times and route schedules. Often, the goal of the SBSP is to minimize the number of buses required by a school district. We extend a time-indexed integer programming model to incorporate additional considerations related to equity and efficiency. We seek to equitably reduce the disutilities associated with changing school start times via a minimax model, then propose a lexicographic minimax approach to improve minimax solutions. We apply our models to randomized instances based on a moderately-sized public school district to show the impact of incorporating equity.

3 - Energy Aware Scheduling of a Material Handling Robot in an m-Machine Robotic Cell

Rabia Taspinar, TOBB University of Economics and Technology, Ankara, Turkey, Hakan Gultekin, Sinan Gurel

In this study, we consider a bi-criteria robotic cell scheduling problem for determining the trade-off between the cycle time and robot's energy consumption in an m-machine cell by the efficient planning of robot movements' sequence and corresponding robot speeds. We proposed two mathematical models and a heuristic algorithm to solve this problem. Their performances are tested by a computational study. Our results indicate that robot speed control can reduce the energy consumption significantly for the same cycle time while providing a set of pareto-efficient solutions for the decision maker.

■ SC33

CC- Room 602

Computational Stochastic Programming

Sponsored: Optimization/Computational Optimization and Software Sponsored Session

Chair: Yankai Cao, BC, Canada

1 - Multistage Adaptive Mixed Integer Optimization Using Improved Piecewise Decision Rule

Zukui Li, University of Alberta, Edmonton, AB, T6G1H9, Canada, zukui@ualberta.ca, Farough Motamed

The decision rule method is popular for multistage adaptive mixed integer optimization under uncertainty. Compared to linear decision rule, piecewise linear decision rule elevates the approximation quality by having multiple slopes (i.e. decision rule coefficients) while inheriting the tractability feature. However, the method relies on the pre-selected breakpoints for each uncertain parameter. This selection may significantly affect the quality of the piecewise decision rule solution. We propose a method to optimize the breakpoint locations with a given number of breakpoints and achieve improved piecewise decision rule for multistage adaptive mixed integer optimization.

2 - A Data-driven Branching on Decomposition of Stochastic Mixed-integer Programs

Kibaek Kim, Argonne National Laboratory, 9700 South Cass Avenue, Building 240, Lemont, IL, 60439, United States, kimk@anl.gov

We consider the dual decomposition of stochastic mixed-integer programs, which is based on the Lagrangian relaxation of the problem with respect to nonanticipativity constraints and known to provide a tight dual bound of the optimal objective value. Due to duality gap, branch-and-bound method may be required for finding a global optimum. We present branching methods in the dual decomposition and the numerical results for comparing different branching methods.

3 - Applications in Optimizing Dynamic Systems under Uncertainty

Bethany Nicholson, Sandia National Laboratories, 5516 Sabrosa Dr NE, Albuquerque, NM, 87111, United States

In this talk we will highlight several applications of combining the PySP, a software framework for stochastic programming, and Pyomo.DAE, a tool for formulating and solving dynamic optimization problems. By combining these frameworks for stochastic programming with dynamic optimization we are able to quickly formulate complex models that directly incorporate uncertainty and system dynamics. Our applications will span a variety of engineering disciplines and demonstrate the value of simultaneously considering dynamics and uncertainty.

4 - A Global Optimization Algorithm for Stochastic Nonlinear Programs

Yankai Cao, University of British Columbia, Vanvouver, BC, Canada, yankai.cao@ubc.ca

We present a reduced-space spatial branch and bound (BB) strategy for two-stage stochastic nonlinear programs. At each node, a lower bound is constructed by relaxing the non-anticipativity constraints and an upper bound is constructed by fixing the first-stage variables. Both lower and upper bounds can be computed by solving individual scenario subproblems. Another key property is that we only need to perform branching on the first-stage variables to guarantee convergence. We present an implementation of the algorithm called SNGO. We also present different heuristics to significantly accelerate the solution process.

■ SC34

CC- Room 603

Supply Chain Management III

Contributed Session

Chair: Fouad El Ouardighi, ESSEC Business School, Cergy Pontoise, 95021, France

1 - A Data-driven Approach for the Price-setting Newsvendor Problem

Mahsa Mardikoraem, University of Wisconsin-Milwaukee, Milwaukee, WI, United States, mardiko2@uwm.edu, Ehsan S. Soofi

Quantile regression has been considered for estimating demand in the price-setting newsvendor problem. In order to incorporate uncertainty about the model, we use Bayesian quantile regression. We apply Stochastic Frontier Models for unobservable censored demands. Our model provides predictive distributions for the optimal quantile of the demand and the expected profit given price.

2 - Competitive Price-matching Policy in a Two-stage Supply Chain

Jinpeng Xu, Xidian University, Xi'an, China, Xiaolan You, Gengzhong Feng

This paper considers a supply chain consisting of a Stackelberg supplier and a retailer selling a product with linear demand function. The retailer decides on whether adopting the competitive price-matching policy under which the consumers can apply to match the lowest price they observe in the market after purchase. We use a Stackelberg game model to derive the optimal wholesale price for the supplier and the optimal retailing price for the retailer when the policy is adopted. We compare the prices and resulting profits with the case without adopting the policy to show when the policy can benefit the retailer and the supplier.

3 - Supply Chain Coordination Mechanisms for Price Dependent Stochastic Demand

Bhavin J. Shah, Associate Professor, Indian Institute of Management-Indore, Indore, Madhya Pradesh, India, bhavinj@iimidr.ac.in, Hasmukh Gajjar

In this paper, we study channel coordination issues with price dependent stochastic demand. We discuss various contracts and conditions to achieve coordination in centralized and decentralized setting. Numerical examples are presented to highlight the theoretical results.

4 - The Price of Myopia and the Price of Anarchy in Supply Chain Analysis

Fouad El Ouardighi, ESSEC Business School, Cergy Pontoise, France, elouardighi@essec.edu, Konstantin Kogan

This paper compares static and dynamic equilibria in a supply chain composed of one manufacturer and one retailer solutions to determine the price of myopia and the price of anarchy.

■ SC35

CC- Room 604

Discrete Optimization and Duality

Sponsored: Optimization/Integer and Discrete Optimization

Sponsored Session

Chair: Temitayo Ajayi, Rice University, Houston, TX, 77004, United States

1 - Projection and Duality

Christopher Ryan, University of Chicago, Chicago, IL, 60637, United States, Lisa Hillis, Guanyi Wang

We expand on a framework proposed by Ryan and Trotter to generalize conic and monoid dualities. We extend to ``affine" settings and explore the relationship between properties of affine dualities with ``projection" properties that generalize the classical notion that polyhedra project to polyhedra. For example, a key property of a duality is the Weyl property, where a set described by ``combinations" of finitely many elements is the intersection of finitely many ``constraints". We show that a duality with a projection property satisfies the Weyl property. Several related conditions are explored with examples and counterexamples that illustrate their significance.

2 - The Gap Function: Evaluating Integer Programming Models Over Multiple Right-hand Sides

Temitayo Ajayi, Rice University, Houston, TX, 77004, United States, ta21@rice.edu

The linear programming relaxation gaps are important to assessing a model's quality for a given set of data. There is no consensus, however, on appropriate measures of model quality when the evaluation considers multiple instances parametrized by right-hand sides of constraints. We propose evaluating models over many right-hand sides by using metrics based on gap functions. In particular, we formulate optimization problems to compute the expectation and extrema of gap functions over bounded hyper-rectangles. These optimization problems are linear programs (albeit of an exponentially large size) that contain at most one special ordered set constraint.

3 - Iterative Combinatorial Auctions for Managing Product Transitions in Semiconductor Manufacturing Using Subadditive Duals of MILP

Ankit Bansal, North Carolina State University, Raleigh, NC, 27606, United States, Osman Ozaltin, Reha Uzsoy

We model the negotiations between multiple product development groups (PDGs) and a manufacturing group (MFG) for access to manufacturing capacity to support product development activities in the semiconductor industry. We develop an Iterative Combinatorial Auction (ICA) framework based on the subadditive duals of MILP that maximizes the number of agents for which a bid is selected in the final solution. We conduct a single shot auction between the auctioneer and MFG at the end where MFG gives the auctioneer a production schedule that improves corporate revenue. The approach aims to achieve coordinated decisions between the two groups with better duality gaps compared to a LP duality based ICA.

4 - Intersection Cuts or Sets with a Distance Oracle

Chen Chen, Ohio State University, Columbus, OH, United States, chenicus@gmail.com

We explore the use of S-free sets, or convex forbidden zones, in order to generate cutting planes for tighter convex relaxations. If S is equipped with a Euclidean distance oracle, then an intersection cut can be generated in polynomial-time. With the appropriate representation, such an oracle is available for mixed-integer linear programming, (nonconvex) polynomial optimization. as well as special sets involving cardinality, or permutations. We also consider implementation issues, including cut strengthening, and exploiting problem sparsity.

5 - Complexity Results for Split Cuts and Disjunctions.

Hongyi Jiang, Johns Hopkins University, Baltimore, MD, United States, hjiang32@jhu.edu, Amitabh Basu

We firstly show that the split closure in two dimensional space has polynomial complexity, which settles an open (to the best of our knowledge) conjecture in integer programming theory. Next, we present a polynomial-time cutting plane algorithm based on split cuts for pure integer programming in two-dimensional space. Finally, we compare the complexity of branch-and-bound and cutting plane algorithms, both based on variable disjunctions, on 0-1 polytopes in general dimensions.

6 - Intersection Cuts for Sets with a Distance Oracle

Daniel Bienstock, Gonzalo Munoz

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7 - Complexity Results for Split Cuts and Disjunctions.

Michele Conforti, Marco Di Summa

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■ SC36

CC- Room 605

Robust Optimization and Mechanism Design

Sponsored: Optimization/Optimization Under Uncertainty

Sponsored Session

Chair: Dan Andrei Iancu, Stanford University, Stanford, CA, 94107, United States

Co-Chair: Daniel Kuhn, Ecole Polytechnique Federale de Lausanne (EPFL), Lausanne, Switzerland, 1015, Switzerland

1 - A Two-layer Multi-armed Bandit Approach for Online Multi-item Pricing

Cagil Kocyigit, Ecole Polytechnique Federale de Lausanne (EPFL), Avenue de Chailly 44, Lausanne, Switzerland, 1012, Switzerland, cagil.kocyigit@epfl.ch, Napat Rujeerapaiboon, Daniel Kuhn

The revenue-maximizing mechanism for selling I items to a buyer with additive and independent values is unknown, but the better of separate item pricing and grand-bundle pricing extracts a constant fraction of the optimal revenue. We study an online version of this pricing problem, where the items are sold to (each of) T identical and independent buyers arriving sequentially. We address this problem with a two-layer multi-armed bandit algorithm (reminiscent of the UCB algorithm) and prove that the proposed online algorithm offers an asymptotic constant-factor approximation guarantee relative to the (unknown) best offline mechanism that benefits from full distributional information.

2 - Prior-Independent Optimal Auctions

Omar Besbes, Columbia University, Graduate School of Business, New York, NY, 10027, United States, ob2105@gsb.columbia.edu, Amine Allouah

Auctions are widely used in practice. While also extensively studied in the literature, most of the developments rely on the significant common prior assumption. We study the design of optimal prior-independent selling mechanisms: buyers do not have any information about their competitors and the seller does not know the distribution of values, but only a general class it belongs to. We characterize properties of optimal mechanisms, and in turn establish fundamental impossibility results through upper bounds on the maximin ratio. By also deriving lower bounds on the maximin ratio, we are able to crisply characterize the optimal performance for a spectrum of families of distributions.

3 - Salesforce Contracting under Uncertain Demand and Supply: Double Moral Hazard and Optimality of Smooth Contracts

Tinglong Dai, Johns Hopkins University, Baltimore, MD, 21202, United States, dai@jhu.edu, Kinshuk Jerath

We consider the compensation design problem of a firm that hires a salesperson to exert effort to increase demand. We assume both demand and supply to be uncertain. Under single moral hazard (i.e., when the salesperson's effort is unobservable to the firm), we show that the optimal contract has an extreme convex form. Under double moral hazard, we show that the optimal contract is smoother to assure the salesperson that the firm does not have an incentive to deviate to an action that will hurt the agent; in fact, under certain conditions, the contract is concave in sales. We also determine conditions under which the firm should postpone contracting until after supply is realized.

■ SC37

CC- Room 606

Robust Sequential Decision Making: Theory and Applications

Sponsored: Optimization/Optimization Under Uncertainty

Sponsored Session

Chair: Hideaki Nakao, University of Michigan, Ann Arbor, MI, 48105, United States

1 - Sensitivity of Preventive Decisions for Deteriorating Markovian Systems

Lauren N. Steimle, University of Michigan, Ann Arbor, MI, 48105, United States, Brian T. Denton

Determining an optimal preventative maintenance strategy for a deteriorating system is common in many application areas including medical decision making, machine maintenance, and forestry management. Markov decision processes (MDPs) have found success in informing preventative maintenance of stochastically deteriorating systems, but there is a concern that the optimal decisions resulting from MDPs are sensitive to model parameters which must be estimated in practice. In this work, we discuss the sensitivity of common MDP formulations for optimal preventive maintenance and illustrate our findings using case studies related to preventive treatment decisions for chronic disease.

2 - Multistage Stochastic and Distributionally Robust Optimization with Prioritization

Xian Yu, University of Michigan, Ann Arbor, MI, 48105, United States, yuxian@umich.edu, Siqian Shen

We consider multistage activity-selection problems with uncertain demand and budget at each stage. We place activities into a priority list before the uncertainty is revealed, and enforce the activity selections to obey the priority list after realizing the uncertainty. The priority list can be either fixed or changing adaptively through stages. In the latter case, we only form the priority list for activities that have not been selected at each stage. We formulate a stochastic integer program and a distributionally robust model. We develop Stochastic Dual Dynamic integer Programming (SDDiP) approach for both two models and test the results using randomly generated instances.

3 - Robust Dynamic Media Selection with Yield Uncertainty: Max-Min Policies and Dual Bounds

Justin Goodson, Saint Louis University, Saint Louis, MO, United States, goodson@slu.edu, Luca Bertazzi, Reuven R. Levary

Uncertainty in exposure yield can degrade advertising effectiveness. Resources available to smaller firms are often inadequate to recapture exposure lost due to bumps before the end of a media campaign. Recognizing the need to buffer against yield uncertainty, we consider strategies to make media buys across time. Our study of static policies motivates the need for dynamic policies, which we show can offer significant advantages. We construct dynamic policies from static policies, and in so doing extend rollout theory to max-min dynamic programs. Because our information-based dual bound is also generally applicable, our work provides tools to both identify policies and to benchmark performance.

4 - Distributionally Robust Partially Observable Markov Decision Process

Hideaki Nakao, University of Michigan, Ann Arbor, MI, 48105, United States, nakaoh@umich.edu, Ruiwei Jiang, Siqian Shen

We consider a distributionally robust formulation of partially observable Markov decision process (POMDP), where the transition probabilities and observation probabilities are assumed to be unknown, and vary over time. We use conic constraints to characterize the moment information for the ambiguity set of the joint distribution of the two types of probabilities. We propose a distributionally robust heuristic search value iteration (DRHSVI) algorithm under a setting where the decision maker obtains the value of the transition and observation probability at the end of every time step.

5 - Sensitivity Analysis of the Inventory Model Governed by Autoregressive Demand Process

Yi Cheng, ISyE Georgia Tech, Atlanta, GA, United States, Guanghui Lan, Alexander Shapiro

Classical analysis of the multistage inventory (newsvendor) model assumes that the involved demand process is stage-wisely independent. In that case the basestock policy is optimal. We consider the setting where the demand is modeled as an autoregressive process and study sensitivity of the corresponding optimal value with respect to the autoregressive parameters. The analysis is based on construction of dual optimization problem and application of the SDDP algorithm.

■ SC38

CC- Room 607

Distributionally Robust Optimization: Modeling, Algorithms, and Applications I

Sponsored: Optimization/Optimization Under Uncertainty

Sponsored Session

Chair: Kibaek Kim, Argonne National Laboratory, Lemont, IL, 60439, United States

Co-Chair: Anirudh Subramanyam, Argonne National Laboratory, Oak Park, IL, 60302, United States

1 - Distributionally Robust Chance Constrained Assignment Problem with an Application to Operating Rooms

Sanjay Mehrotra, Northwestern University, Dept of I. E. / M. S. C246 Tech Inst, 2145 Sheridan Road, Evanston, IL, 60208-3119, United States, mehrotra@iems.northwestern.edu, Shanshan Wang, Jinlin Li

We study a class of assignment problems with distributionally robust chance constraints. We show how to use the robust framework towards strengthening the big-M coefficients. We also use a bi-linear formulation of the problem and provide ways to identify strengthen cover inequalities. We present computational results for a branch-and-cut implementation of our problem. We also show the value of including distributional robustness using l1 Wasserstein metric.

2 - Distributionally Robust Nonlinear Optimization

Jianzhe Zhen, École Polytechnique Fédérale de Lausanne (EPFL), Rijtse Akkers 174, Lausanne, 5037JW, Switzerland, jianzhe.zhen@epfl.ch, Daniel Kuhn, Wolfram Wiesemann

Leveraging a generalized `primal-worst equals dual-best' duality scheme for robust optimization, we derive from first principles a strong duality result that relates distributionally robust to classical robust optimization problems and that obviates the need to mobilize the machinery of abstract semi-infinite duality theory. In order to illustrate the modeling power of the proposed approach, we present convex reformulations for data-driven distributionally robust optimization problems whose ambiguity sets constitute type-p Wasserstein balls for any p in [1,\infty].

3 - Distributionally Robust Expectation Using Shape Information

Ruiwei Jiang, University of Michigan, Ann Arbor, MI, 48109, United States, ruiwei@umich.edu, Yuanyuan Guo

This talk discusses the expectation of a random function when the distributional information of the uncertain parameters consists of moment (e.g., mean, covariance, support) and probabilistic dominance information. We find that the expectation in this setting can be bounded using conic programming. Finally, we demonstrate the theoretical results via case studies on appointment scheduling.

4 - Two-stage Wasserstein Distributionally Robust Convex Programs with Zero-one Uncertainties

Anirudh Subramanyam, Argonne National Laboratory, Lemont, IL, 60302, United States, Mohamed El Tonbari, Kibaek Kim

We address discrete-valued zero-one random parameters in two-stage convex conic optimization problems in which the goal is to minimize the worst-case expectation of the random cost, over all distributions in a Wasserstein ball centered at the empirical distribution. We provide a simple, tractable and scalable technique that provides a conservative approximation. Our method relies on a reformulation that constrains some variables to lie in the convex hull of feasible points of a mixed-integer conic set, followed by an approximation of this convex hull using lift-and-project techniques. Numerical experiments illustrate the practical viability and benefits of our method over existing schemes.

■ SC39

CC- Room 608

RAS Student Paper Competition

Sponsored: Railway Applications

Sponsored Session

Chair: Nikola Besinovic, Delft University of Technology, Delft, 2600CN, Netherlands

Co-Chair: Qing He, University at Buffalo, SUNY, Buffalo, NY, 14260, United States

1 - Solving Cyclic Train Timetabling Problem through Model Reformulation: Extended Time-space Network Construct and Alternating Direction Method of Multipliers Methods

Yongxiang Zhang, Southwest Jiaotong University, Chengdu, 610031, China

In this research, the cyclic train timetabling problem is reformulated through an extended time-space network construct. The resulting integer programming model can be efficiently solved with the Alternating Direction Method of Multipliers.

2 - Short-term Forecasting of Origin-Destination Matrix in Rail System via a Deep Learning Approach

Yuxin He, City University of Hong Kong, 83 Tat Chee Avenue, Kowloon Tong, Hong Kong, 518000, Hong Kong

This paper develops an innovative deep learning approach, named Multi-Fused Residual Network (MF-ResNet), to forecast short-term OD matrix in rail transportation networks. The experimental results show that MF-ResNet can well capture the complex dependencies and outperforms state-of-art baselines.

3 - Passenger-centered Vulnerability Assessment of Railway Networks

Christopher Szymula, Technische Universität Dresden, Leipzig, Germany

This paper introduces a model for assessing passenger-centered railway network vulnerability. Embedded in a framework, it provides the networks critical links, passenger flows and train operations. The performance is shown on a case study.

■ SC40

CC- Room 609

Optimization for Statistical Learning

Sponsored: Optimization/Nonlinear Programming

Sponsored Session

Chair: Sam Davanloo Tajbakhsh, Ohio State University, Columbus, OH, 43210, United States

1 - High Dimensional Stochastic Optimization under Low Rankness

Hongcheng Liu, University of Florida, Gainesville, FL, 32606, United States, Charles Hernandez, Hung Yi Lee

The talk concerns high-dimensional a stochastic programming problem of minimizing the expected function of a matrix argument. To this problem, the traditional sample complexity theories of the sample average approximation require the sample size to be polynomial in the problem dimensionality. Such a sample requirement becomes easily prohibitive when optimizing functions of matrix arguments. Indeed, for a problem optimizing over a p-by-p matrix, the sample complexity grows rapidly at a quadratic rate in p. To reduce the sample complexity this paper considers a low-rankness-inducing regularization scheme and shows that the sample complexity can be substantially reduced to almost linear in p.

2 - On Push Pull Gradient Methods for Distributed Optimization Over Directed Graphs in Absence of Strong Convexity

Mostafa Amini, Oklahoma State University, Stillwater, OK, 74075, United States, moamini@ostatemail.okstate.edu, Farzad Yousefian

We consider distributed optimization in multi-agent systems where each agent is associated with a merely convex function and agents communicate over a directed graph. The goal is to collaboratively minimize the sum of the cost functions. We develop an iteratively regularized distributed push-pull gradient method where the decision variable information is pushed to the neighbors and the gradient information is pulled from the neighbors. We establish the convergence of the method and derive a rate statement. Preliminary numerical results for a big data application will be discussed.

3 - Fair Rényi Inference

Sina Baharlouei, University of Southern California, OHE 340, Los Angeles, CA, 90089, United States, baharlou@usc.edu

Machine learning algorithms have been increasingly deployed in critical automated decisions that directly affect human lives. Several reported instances have demonstrated that these algorithms may suffer from systematic discrimination against individuals based on their sensitive attributes (gender, race,). In this talk, we introduce Hirschfeld-Gebelein-Rényi (HGR) correlation principle as a tool to impose several known group fairness measures. Using HGR coefficient, we propose a min-max game formulation for fair statistical inference. Our framework leads to natural fair supervised and unsupervised learning methods which enjoy theoretical performance guarantees.

4 - An Alternating Direction Method of Multipliers with the Sharing Scheme for Statistical Learning under Structured Sparsity

Dewei Zhang, The Ohio State University, Columbus, OH, United States, zhang.8705@osu.edu, Yin Liu, Sam Davanloo Tajbakhsh

To achieve more interpretable statistical models, sometimes it is preferred that the learning solution obeys an a priori known hierarchical structure represented as a directed acyclic graph. Inducing such structures requires nonsmooth penalty functions that exploit group overlapping of the decision variables. Our study focuses on the optimization problems with such penalties. We develop an ADMM algorithm with the sharing scheme to solve high-dimensional instances of these problems. In the absence of strong convexity, linear convergence of the algorithm has been established provided a primal and dual error bound. Some numerical results supporting the proposed algorithms will be provided.

■ SC41

CC- Room 610

Conic Mixed Integer Programming

Sponsored: Optimization/Linear and Conic Optimization

Sponsored Session

Chair: Sven Wiese, Mosek ApS, Copenhagen, 2100, Denmark

1 - Conic Optimization in Mosek 9: New Cones and Algorithms

Sven Wiese, Mosek ApS, Copenhagen, Denmark, sven.wiese@mosek.com

Conic optimization is a popular paradigm because it preserves many desirable properties of Linear Programming, but is also quite versatile when it comes to modeling. In fact, the by now accepted folklore is that the linear, quadratic, semidefinite, exponential and power cones are enough to express almost all practical convex optimization problems. The software package MOSEK has for a long time been able to optimize over the former three, the symmetrical cones. The new version 9 also handles the latter two, the non-symmetric ones. This talk gives an overview on applications of this breakthrough, and on the employed algorithms, both in the continuous and mixed-integer case.

2 - A Branch-and-cut Algorithm for Solving Mixed-integer Semi-definite Optimization Problems

Ken Kobayashi, Fujitsu Laboratories LTD., Kawasaki, Japan, ken-kobayashi@fujitsu.com, Yuichi Takano

We consider a cutting-plane algorithm for solving mixed-integer semidefinite optimization (MISDO) problems. In this algorithm, we relax the positive semidefinite (psd) constraint, and solve the resultant mixed-integer linear optimization problem repeatedly, imposing at each iteration a valid inequality for the psd constraint. Moreover, to speed up the computation, we devise a branch-and-cut algorithm, in which we add valid inequalities dynamically during a branch-and-bound procedure. Our numerical experiments showed that, for many problem instances, our branch-and-cut algorithm outperformed other general-purpose MISDO solvers in terms of computational efficiency and stability.

3 - On the Circuit Diameter Conjecture

Tamon Stephen, Simon Fraser University, Surrey, BC, Canada

A key concept in optimization is the diameter of a polyhedron. From the point of view of optimization, we would like to relate it to the number of facets f and dimension d of the polyhedron. Following Klee and Walkup (1967), we consider analogous questions for a variant of the combinatorial diameter called the circuit diameter. Here paths are built from the circuit directions of the polyhedron, and can travel through the interior. We show that many of the Klee-Walkup results and techniques translate to the circuit setting. Joint work with Steffen Borgwardt and Timothy Yusun.

4 - Convex Hull Representations for Bounded Products of Variables

Kyungchan Park, University of Iowa, Iowa City, IA, United States, kyungchan-park@uiowa.edu, Kurt M. Anstreicher, Samuel Burer

Convex hull for {(x,y,z) z=xy, 0≤x,y≤1} is given by Reformulation-Linearization Technique (RLT) constraints. Belotti et al. (2010) and Miller et al. (2011) derived convex hull with additional upper/lower bounds on z as an infinite family of inequalities, requiring a separation algorithm to implement. We show the convex hull for upper or lower bounded product is given by original RLT constraints, the bound on z, and a single SOC constraint. For upper/lower both bounded product, we show convex hull remains SOC-representable on a dissection of the domain of (x,y). Also, volumes of the feasible space with bounds on z are calculated and compared to the relaxation that imposes only the RLT constraints.

■ SC42

CC- Room 611

Analysis and Optimization of Critical Infrastructure Systems

Sponsored: Optimization/Network Optimization

Sponsored Session

Chair: N. Orkun Baycik, Shenandoah University, Winchester, VA

1 - Enhancing Resilience of Complex Infrastructure Components

Cameron MacKenzie, Iowa State University, Industrial and Manufacturing Systems Engr, Ames, IA, 50011, United States, camacken@iastate.edu, Ramin Giahi

Critical infrastructure components should be designed to be resilient to sudden and adverse events. The design should also incorporate future maintenance decisions about whether to repair or replace worn-out components. Many designs of critical infrastructure require complex simulations, which can be difficult to optimize. We apply Bayesian optimization techniques to optimize the design and maintenance of resilient critical infrastructure.

2 - A Hybrid Data-driven Game-theoretic Optimization Framework for Resilient Interdependent Infrastructure Networks

Alireza Rangrazjeddi, University of Oklahoma, Norman, OK, 73019, United States, ajeddi@ou.edu, Andres David Gonzalez, Kash Barker

Infrastructure networks are constantly under natural and anthropogenic hazards that may affect their performance and the communities they serve. Thus, it is imperative to propose efficient modeling techniques that support adequate decision-making before and after disruptive events. However, infrastructure networks are complex systems that involve multiple interdependencies and stakeholders with goals that are not always aligned. To address these issues, we propose a hybrid data-driven game-theoretic optimization framework to develop efficient mitigation and recovery plans for systems of interdependent infrastructure networks with multiple decision makers involved.

3 - Modeling the Interdependency of Emergency Services and Power Outages During Critical Events

Ann Suhaimi, Northeastern University, Boston, MA, 02115, United States, nmsuhaimi@gmail.com, Jacqueline Griffin

Effective emergency medical services (EMS) are crucial in promoting safety and health of populations especially during critical events. While a lot of studies on network optimization have considered the role of transportation networks, the reality of most emergency response lies indirectly on power networks as demand for EMS are dependent on power availability. We model our EMS network based on an existing power network in Greater Boston Area and integrate the probability of demand for emergency services during critical events coupled with power outages based on historical data. MIP model is developed to minimize both the response time of emergency services and the cost of virtual power generation.

4 - An Interdiction-based Approach to Identify Damage in Interdependent Critical Infrastructures

N. Orkun Baycik, Shenandoah University, School of Business, Winchester, VA, 22601, United States, Thomas Sharkey

We study the problem of determining the damage in multiple interdependent infrastructures given outage reports from the customers (or service receivers). Demand nodes within these infrastructure networks may have an outage either from damage that occurred within its infrastructure or due to cascading failures across infrastructures. We present a network interdiction based approach to identify the order in which components should be inspected in order to determine the damage within these networks based on the outages reported by customers.

■ SC43

CC- Room 612

Joint Session ICS/Practice Curated: Binary Decision Diagrams Applications

Sponsored: Computing

Sponsored Session

Chair: Leonardo Lozano, University of Cincinnati, Cincinnati, OH, 45219, United States

1 - A Decision Diagram Based Integer Programming Formulation for the Paired Job Scheduling Problem

Leonardo Lozano, University of Cincinnati, Cincinnati, OH, 45219, United States, leolozano@uc.edu, Michael Magazine, George G. Polak

The paired job scheduling problem seeks to schedule n jobs in a single machine, each one consisting of two tasks for which there is a mandatory minimum waiting time between the completion of the first task and the start of the second task. We provide complexity results for problems defined by three commonly used objective functions. We propose an integer programming formulation based on a decision diagram decomposition that models the objective function and some of the challenging constraints in the space of the diagrams flow variables. Computational results show a that our proposed model performs considerably better than a standard time-indexed formulation over a set of randomly generated instances.

2 - A Network-based Formulation for Scheduling Clinical Rotations

Andre Augusto Cire, University of Toronto Scarborough, Department of Management, UTSC, 1265 Military Trail, Toronto, ON, M1C-1A4, Canada, acire@utsc.utoronto.ca, Adam Diamant, Tallys Yunes, Alejandro Carrasco

We investigate the practices of a medical school that must assign a cohort of students to a series of clinical rotations. We propose a network-flow model that leverages the structure of the data to compactly represent feasible schedules. Such a model can be used either to find optimal assignments when incorporated into a mathematical programming formulation, or to provide insights as to the cost sensitivity of the various problem parameters. Our analysis also indicates significant cost reductions in comparison to current scheduling policies.

3 - Embedding Perfect Structures in Process Systems

Arvind Raghunathan, Mitsubishi Electric Research Laboratories, Cambridge, MA, 02139, United States, raghunathan@merl.com

Combinatorial Optimization (CO) problems are significantly challenging to solve, in spite of impressive progress in the development of robust, commercial mixed integer programming solvers. In this talk, we propose the idea of embedding perfect structures (convex hulls) in the formulations using Decision Diagrams. We explain our formulation methodology through two applications in Electricity Generation (Unit commitment) and Heat Exchanger Design (Heating, Ventilation and Air Conditioning). In each of these cases we show that our approach provides significant improvement over state-of the-art algorithms in the respective problem domains.

4 - Optimization Algorithms for the Bin Packing Problem with Minimum Color Fragmentation

Saharnaz Mehrani, University of Connecticut, Storrs, CT, United States, David Bergman, Carlos Henrique Cardonha

In the bin packing problem with minimum color fragmentation (BPPMCF), we are given a bounded number of bins, a collection of items each with a size and a color, and the goal is to use as few bins as possible to pack items of the same color. This problem has several real-world applications in areas as diverse as accommodation assignment in sport events, production planning, logistics, and health care. In this work, we present several exact optimization algorithms to solve BPPMCF, including mixed-integer programming formulations, a branch-and-price algorithm, and two decision diagram-based algorithms. Our computational experiments show the efficiency of our proposed algorithms.

5 - End to End Learning and Optimization on Graphs

Bryan Wilder, University of Southern California, Los Angeles, CA, 90016, United States, bryan.wilder0@gmail.com, Eric Ewing, Bistra Dilkina, Milind Tambe

Real-world applications often combine learning and optimization problems on graphs. E.g., edges are often only partially observed, introducing a link prediction problem which must be solved prior to a decision problem (such as locating facilities, partitioning the graph, etc). We propose an approach to integrate a differentiable proxy for common graph optimization problems into machine learning training. This focuses training specifically on the downstream task that the predictions will be used for. Our end-to-end system performs better on example optimization tasks than can be obtained by combining state of the art link prediction with expert-designed graph optimization algorithms.

■ SC44

CC- Room 613

Machine Learning for Discrete Optimization

Sponsored: Computing

Sponsored Session

Chair: Bistra Dilkina, University of Southern California, Los Angeles, CA, 90089, United States

1 - Learning to Solve the Unit Commitment Problem

Alinson Santos Xavier, Argonne National Laboratory, Lemont, IL, United States, axavier@anl.gov, Feng Qiu, Shabbir Ahmed

Unit Commitment (UC) is a fundamental problem in power systems, being solved daily to clear the energy markets. In practice, UC is repeatedly solved via Mixed-Integer Linear Programming (MILP) with only minor changes in input data. In this work, we propose a number of machine learning (ML) techniques to extract information from previously solved instances in order to improve the computational performance of MILP solvers when solving similar instances in the future. Computational results on a diverse set of realistic and large-scale instances show that UC can be solved on average 12 times faster, with no negative impact on solution quality.

2 - Neural Integer Optimization: Learning to Satisfy Generic Constraints

Elias B. Khalil, Polytechnique Montréal, Montréal, QC, 30309, Canada, lyes@gatech.edu, Rakshit Trivedi, Bistra Dilkina

There has been a recent surge in research on learning heuristics for combinatorial optimization problems over a distribution of instances. Despite promising results on problems such as the TSP, existing learning methods are only capable of handling simple constraints. Our work is an attempt at learning heuristics for discrete optimization problems subject to general linear inequalities. The key contribution lies in incorporating projection into a recurrent neural network model that generates soluti

ons to a discrete optimization problem with intricate constraints. We show promising results on instances from various classes of discrete optimization problems.

3 - A Language Processing Algorithm for Predicting Tactical Solutions to Operational Planning Problems under Uncertainty

Emma Frejinger, Universite de Montreal, FAS, Pavillon Andre-Aisenstadt, Montreal, QC, H3C 3J7, Canada, Eric Larsen, Andrea Lodi

We focus on predicting tactical (high-level) solutions to operational planning problems in short computing time under uncertainty. This work extends Larsen et al. 2018 (arXiv:1807.11876) by predicting more detailed, variable-length solutions. The machine learning model originates from language processing and we construct vocabularies and syntax describing the problem instances and solutions. Extensive numerical results for an application on train loading demonstrate excellent predictive accuracy and very short computing times.

4 - Robust Optimization under a Machine Learning Lens

Liangyuan Na, Massachusetts Institute of Technology, MIT, Cambridge, MA, United States, lyna@mit.edu, Dimitris Bertsimas, Bartolomeo Stellato

We propose an interpretable machine learning framework for robust optimization. For different classes of continuous and discrete robust optimization problems we obtain insights on the logic behind the optimal solutions. Our approach allows us to understand robust solutions by learning the relationship between the problem parameters and the worst case uncertainties in the problem data. With several examples we show that our method not only achieves high accuracy and interpretability, but is also able to compute the optimal solutions at higher speed than state-of-the-art algorithms.

■ SC45

CC- Room 614

Continuous-time Perspective in Optimization

Sponsored: Optimization/Nonlinear Programming

Sponsored Session

Chair: Jelena Diakonikolas

1 - Worst-case Algorithm Analysis: Bridging Discrete and Continuous Time

Laurent Lessard, University of Wisconsin-Madison, Madison, WI, United States, laurent.lessard@wisc.edu

Iterative optimization algorithms are often analyzed in terms of their worst-case performance. Such analyses can be directly carried out on the iterative algorithm (discrete time analysis), or one can study the continuous-time limit, or gradient flow, which is an ordinary differential equation (ODE). While these two approaches often agree, there are important cases where they do not. This talk will explore some fundamental differences between discrete- and continuous-time analyses by relating them to established concepts from robust control theory, such as the Lur'e problem and the Aizerman and Kalman conjectures.

2 - Achieving Acceleration via Direct Discretization of Heavy-ball ODE

Jingzhao Zhang, Massachusetts Institute of Technology, Cambridge, MA, United States, Aryan Mokhtari

We study gradient-based methods obtained by directly discretizing a second-order ODE related to the continuous limit of Nesterov's accelerated gradient method. When the function is smooth enough, we show that acceleration can be achieved by a stable discretization of this ODE using standard Runge-Kutta integrators. We prove that under smoothness, convexity, and order-(s+2) differentiability assumptions, we obtain at a rate of $O(N^{-2s/(s+1)})$, where s is the order of the Runge-Kutta numerical integrator. We also introduce a new local flatness condition on the objective, under which rates even faster than $O(N^{-2})$ can be achieved with low-order integrators and only gradient information.

3 - A Variational Approach to the Design of First-order Methods via Self-dual Convex Functionals Over Path Space

Lorenzo Orecchia, Boston University, Boston, MA, 02215, United States

We present a novel approach to analyze and design first-order methods for convex optimization via the calculus of variation. Specifically, we show that the continuous-time dynamics underlying these methods arise as the unique solutions of the minimization of natural convex functionals over the space of absolutely continuous paths from a given starting point. While previous work has characterized these continuous-time dynamics as critical points of certain functionals, i.e., solutions to Euler-Lagrange equations, our work is the first to give a convex formulation of these functionals.

4 - A Hamiltonian Perspective on Momentum-based Methods

Jelena Diakonikolas, UC Berkeley, 475 Evans Hall, Berkeley, CA, 94720, United States, Michael I. Jordan

We shed new light on momentum-based methods by showing that a broad class of methods that contains Nesterov's accelerated method and Polyak's heavy ball method can be generated as equations of motion of a certain class of time-varying Hamiltonians. We further show that the Hamiltonians generating the equations of motion lead to invariants that can be used to analyze the convergence of these methods in the settings of both convex and non-convex optimization.

■ SC46

CC- Room 615

Risk and Disruption Management in Transportation Systems

Sponsored: Transportation Science & Logistics/Intelligent Transportation Systems (ITS)

Sponsored Session

Chair: Elise Miller-Hooks, George Mason University, Silver Spring, MD, 20905, United States

Co-Chair: Changhyun Kwon, University of South Florida, Tampa, FL, 33620, United States

1 - Pessimistic Bilevel Toll Pricing Problem for Mitigating Hazardous Materials Transport Risk

Mahdi Takalloo, University of South Florida, Tampa, FL, 33613, United States, mtakalloo@mail.usf.edu, Joey Huchette, Changhyun Kwon

We study the pessimistic bilevel toll pricing problem for mitigating the risk of transporting hazardous materials. We compare the pessimistic and the optimistic hazmat toll pricing problems and study the existence of a solution to those problems. We use disjunctive programming to formulate an approximation to the pessimistic problem and develop solution approaches.

2 - Enhancing Roadway Network Resilience to Disruptions from Maintenance and Restoration Activities

Sohrab Mamdoohi, George Mason University, 9916 Fairfax Square, # 54, Fairfax, VA, 22031, United States, Elise Miller-Hooks

Roadway maintenance & restoration activities impact traffic, interrupting network equilibria conditions. An analytical model is presented that jointly optimizes maintenance/restoration downtime scheduling & traffic diversion strategies with the aim of mitigating the impact of roadway downtime, & enhancing system resilience. The system is resilient if an equilibrium is quickly re-established.

3 - Road Network Pricing and Design for Ordinary and Hazmat Vehicles. Integrated Model and Specialized Local-search

Armando Gabriel Guarnaschelli, Pontificia Universidad Católica de Valparaíso, Brasil 2147, Valparaíso, Chile, armando.guarnaschelli@pucv.cl, López-Ramos Francisco, Stefano Nasini

We propose an optimization framework to integrate a road operator s decisions on network tolling, regulation, and expansion, accounting for vehicle flow carrying hazardous materials. A mixed-integer nonlinear bi-level problem represents the operator (acting as a leader), and a set of vehicles (acting as a follower) that flow through the network. The leader maximizes its profit, composed of toll incomes minus construction costs and risk costs induced by hazmat vehicle circulation. The follower minimizes toll charges and the cost of travel time increased by congestion. A reformulation approach reduces the problem's complexity. Moreover, we provide an efficient mechanism to solve it.

4 - Stochastic Multi-player Investment Optimization for Maritime Port Network Resiliency and Reliability

Ali Asadabadi, FedEx, Germantown, TN, 38138, United States, Elise Miller-Hooks

This work develops stochastic, bi-level, game theoretic optimization models for assessing and improving the resiliency and reliability of a maritime shipping network, specifically the port network, connected through liner shipping service routes. The proposed models account for port-related disruptions and their rippling consequences that cascade across the maritime system. The models seek optimal protective investments accounting for a competitive, but potentially cooperative (co-opetitive) environment.

■ SC47

CC- Room 616

Health Care, Modeling and Optimization I

Contributed Session

Chair: Ping Zhang, Hong Kong Polytechnic University, Hung Hom, Kowloon, Hong Kong, China

1 - Predicting Hospital Choice Decision Based on EHR Information

Bowen Pang, Tsinghua University, Beijing, China, Xiaolei Xie, Haibo Wang

Residents with critical diseases in China often prefer to visit larger hospitals in another province, which results in tremendous service burden to well-known hospitals in major cities. This phenomenon increases the waiting time of patients and reduces the quality of care services. In this work, we analyze the factors influencing the hospital choice of inpatients and formulate a predictive model on the decision of patients including whether to see care services in non-local provinces as well as the selection of provinces and hospitals based on demographic and disease-related information.

2 - The Operational Performance of Hospital: The Effect of Telemedicine on Chronic Care

Ji Fang, Southeast University, Nanjing, China, itfangji@163.com, Haiyan Wang

A large number of patients with chronic diseases do not seek treatment because of the traveling costs and waiting costs. Telemedicine is an effective way to short the traveling distance and improve the medical resources utilization. We study a non-profit hospital whether should offer telemedicine and how to allocate the service level to face-to-face service and telemedicine service. The results show that the ratio of patients who receive treatment will increase when the hospital offering telemedicine in the limited service capacity. We also provide the optimal distribution of service level on dual-channel.

3 - Hospital Emergency Overflow Utilization Planning and Analysis using Simulation

Abelardo Mayoral Fierros, Fraser Health Authority, Surrey, BC, Canada, Nazanin Shabani

Population growth and aging in BC communities have resulted in congestion in some of the hospitals in past several years. Emergency departments have been experiencing a high number of inpatient admissions waiting for placement in an inpatient bed. Overflow beds can be a temporary solution to balance the load between the ER and other inpatient units during peak hours. A discrete event simulation model was developed to help a hospital leadership team to study different configurations of overflow capacity location for medicine inpatients waiting for placement in an acute care bed. The model results identified the optimum number of flow beds while quantifying the impact in ER occupancy and patient flow.

4 - Modelling the Large-scale Hospital by Discrete-event Simulation

Chengye ZOU, The University of Hong Kong, Hong Kong, Hong Kong, zcypaul@hku.hk

The large-scale hospital makes the medical resources connected, where the poor system management can lead to low efficiency, long waiting time and extra healthcare expenditure. In this research, a large-scale hospital is modeled by discrete-event simulation, including several outpatient clinics and examinations, with changeable doctors' schedules and patients' arrival distributions. The measurement and evaluation of the efficiency of the system are discussed by experiments.

5 - The Impacts of Medical Inventory Sharing on Hospital Returns in Consignment Contracts

Ping Zhang, The Hong Kong Polytechnic University, Hong Kong, China, ping.zp.zhang@connect.polyu.hk, King Wah Pang, Hong Yan

Hospitals adopt consignment contract to purchase disposable medical items. When a hospital anticipates stockout, another hospital may have excess inventory and need to return to dealer. We propose a dealer-dominated inventory sharing policy between two independent hospitals which have a common dealer. We aim at exploring whether the sharing policy can benefit dealer and hospitals by reshaping the return policy.

■ SC48

CC- Room 617

Joint Session TSL/FRT/Practice Curated: General Freight Transportation 1

Sponsored: Transportation Science & Logistics/Freight Transportation & Logistics

Sponsored Session

Chair: Sandra D. Eksioglu, Clemson University, Clemson, SC, 29634, United States

1 - Modeling Shifts in World-wide Maritime Flows in a Changing Global Landscape

Wenjie Li, George Mason University, Fairfax, VA, United States, Elise Miller-Hooks

This presentation presents modeling techniques for analyzing shifts in world-wide maritime flows associated with international trade of bulk and container cargo. A changing global landscape, including: changes in maritime shipping route and interior railway corridor characteristics; port capabilities, capacities and operations; ocean carrier alliances; and vessel dimensions, are considered in assessing changing trends in optimal global flows.

2 - Designing a Centralized Marketplace for Transportation Services - A Framework to Ensure Equitable Distribution

Arim Park, North Carolina A&T State University, Greensboro, NC, 07102, United States, Mark Rodgers, Soohyun Cho, Yao Zhao

We would like to design an efficient mechanism for an electronic market of transportation services (trucking) in Korea. Under such a market mechanism, shippers get what they pay for (best services at the lowest price) and all service providers (truckers), large or small, have an equal chance to compete.

3 - Logistics Network Design for Fresh Flowers

Alan Erera, Georgia Institute of Technology, School of Industrial & Systems Eng, Atlanta, GA, 30332-0205, United States, alan.erera@isye.gatech.edu, Yaarit Cohen, Jonathan Zribi, Benoit Montreuil

The floral industry is a global, dynamic, rapidly growing industry. In China, 70% of domestic flower transportation is currently conducted using air transport. Although air transport is faster, it is more costly than ground transportation and does not provide the temperature control required to maximize flower freshness. We consider the design of a ground transportation network for fresh flowers in China. We build a path-based time-expanded network design model to minimize logistics costs. The model attempts to fulfill as much demand as possible by ground transport, and incorporates a model of flower freshness decay and perishability that limits which demand can be feasibly served by trucking.

■ SC49

CC- Room 618

Joint Session TSL/Urb/Practice Curated: Data-Driven Optimization for Urban Transit

Sponsored: Transportation Science & Logistics/Urban Transportation

Sponsored Session

Chair: Julia Y Yan, Massachusetts Institute of Technology, Cambridge, MA, 02143, United States

Co-Chair: Dimitris Bertsimas, Massachusetts Institute of Technology, Cambridge, MA, 02139, United States

1 - The Edge of Optimization in Large-scale Vehicle Routing for Paratransit

Julia Y. Yan, Massachusetts Institute of Technology, 10 Stanford Terrace, Cambridge, MA, 02143, United States, jyyan@mit.edu, Dimitris Bertsimas

The Americans with Disabilities Act (1990) mandates that door-to-door transit be made available to people who cannot use fixed routes due to disability. While “paratransit” is a critical safety net, it is also very costly. Our goal is to reduce costs by developing quality routing algorithms that find efficient routes and account for service quality, labor regulations, and vehicle availability. We take a hierarchical approach that can run in an hour, and test our algorithm on real data from Boston with over 7,000 requests. Our algorithm improves upon Boston’s current productivity by 10%.

2 - From Transportation to Policy: Optimizing School Start Times and Bus Routes

Arthur J. Delarue, Massachusetts Institute of Technology, Cambridge, MA, 02139, United States, Dimitris Bertsimas, Sebastien Martin

Spreading start times allows school districts to reduce transportation costs by reusing buses between schools. However, assigning each school a time involves both estimating the impact on transportation costs and reconciling additional competing objectives. These challenges force many school districts to make myopic decisions, leading to an expensive and inequitable status quo. We propose an algorithm to jointly solve the school bus routing and bell time selection problems. Our application in Boston led to $5 million in yearly savings (maintaining service quality despite a 50-bus fleet reduction) and to the unanimous approval of the first school start time reform in 30 years.

3 - Transit Integration with Multiple Providers

Yeesian Ng, Massachusetts Institute of Technology, Cambridge, MA, 02139, United States, Dimitris Bertsimas, Julia Y. Yan

In many regions, individual travel needs often extend beyond the service area of a single agency. As a result, many commuters need to make transfers between different transit services. However, when multiple transit services are taken into account for integration, the scale of the networks makes it difficult to manually synchronize the schedules of the various services. We develop data-driven formulations for coordinating between multiple transit operators in multi-modal networks while synchronizing transfers across connecting services and accounting for operator budget concerns.

4 - Reliable Frequency Regulation Through Vehicle-to-grid

Dirk Lauinger, PhD Student, Ecole Polytechnique Fédérale de Lausanne (EPFL), Lausanne, Switzerland, dirk.lauinger@epfl.ch, Francois Vuille, Daniel Kuhn

Vehicle-to-grid aims to increase the low utilization of electric vehicles by making their batteries available to the power grid. We formulate an optimization problem that maximizes the expected profit from selling primary frequency regulation to the power grid, while guaranteeing that all market commitments can be met for all frequency deviations in an uncertainty set informed by new EU legislation. Depending on the charger and battery size annual profits range from 83 Euro to 165 Euro per vehicle in 2018. We show that profits increase with charger size only up to a certain threshold, above which they saturate, contradicting the predictions of existing deterministic models.

■ SC50

CC- Room 619

Modeling and Technology Innovations for Facility Logistics

Sponsored: Transportation Science & Logistics/Facility Logistics

Sponsored Session

Chair: Debjit Roy, Indian Institute of Management, Ahmedabad, 560078, India

1 - A Grid-based Goods-to-Person Order Picking System

Mina Shekari, University of Louisville, Louisville, KY, United States, Kevin Gue

As robotic arms replace humans for e-commerce order picking, there will be a need to feed these robots at ever higher rates of product totes per minute. We describe a grid-based goods-to-person order fulfillment system that uses decentralized control to move items quickly to and from picking stations on any side of the grid. We prove some throughput bounds and show how the grid-based system compares.

2 - Collaborative Order Picking with Pick-support AGVs

Alexandros Pasparakis, Rotterdam School of Management, Rotterdam, Netherlands, pasparakis@rsm.nl, Jelle De Vries, René De Koster

Automated guided vehicle (AGV) systems may be used to support the manual order picking process in warehouses. We conducted an experiment to compare multiple scenarios and see what collaboration system (human leading vs robot leading) leads to the best picker performance, satisfaction, and self-evaluation, based on individual picker personality attributes. Results indicate that promotion focused individuals and individuals with external work locus of control tend to underperform while being led by robots (compared to when they lead the robots). Evidence that the collaboration with AGVs may negatively affect the picker self-evaluation (self-efficacy & self-esteem) was also established.

3 - Stochastic Model for Integrated Storage-Order Picking System with Multi-Line Orders

Vishal Bansal, Indian Institute of Management Ahmedabad, Ahmedabad, 380015, India, fpm16vishalb@iima.ac.in, Debjit Roy

Due to demanding service levels in e-commerce order fulfillment, modeling and analysis of integrated storage and order picking processes in warehouses deserve special attention. With a particular focus on multi-line e-commerce orders, we develop a queuing network modeling framework for integrated analysis of upstream (SBS/R system) and downstream (pick system) networks. We also propose a novel hybrid simulation/analytic model to evaluate performance measures. We analyze the effect of the storage system configuration on the order throughput time at pick station. The results indicate that the hybrid simulation/analytic approach works best in the estimation of the performance measures.

4 - A Hybrid Genetic Algorithm for Online Batching in High Throughput Poultry Processing Lines

Bert Hundscheid, Eindhoven University of Technology, Eindhoven, Netherlands, Kay Peeters, Jelle Adan, Tugce Martagan, Ivo Adan,

We consider batching processes in high throughput poultry processing lines. The key objective is to form batches of arrivingitems that minimize the difference between the actual and targetbatch weight. Items are allocated first-come-first-serveddiscipline to available bins in the batching machine and the exactweight of items is known over a given horizon of arriving items. Wedevelop a hybrid algorithm combining a genetic algorithm and localsearch methods to assignt items to the available bins. Simulationsbased on real-world data suggest that the proposed algorithmproduces high quality solutions within a feasible time limit.

5 - Being Responsive or Efficient in Order Picking

Jelmer Pier van der Gaast, Fudan University, Shanghai, China

In many order picking systems during the day there are several moments of time criticality, e.g., delivery trucks are scheduled to depart from the warehouse. Warehouse companies normally want to be efficient in their resources as this reduces the operating costs, but need to be responsive when deadlines are coming up. However, being responsive is only required at time criticality moments as it would otherwise increase the operating costs of the warehouse significantly. We develop a mathematical model that determines when and for how long the order picking process should be efficient or responsive by either changing the way of order picking or by changing the number of resources in the system.

■ SC51

CC- Room 620

AAS Best Student Presentation Competition III

Sponsored: Aviation Applications

Sponsored Session

Chair: Heng Chen, University of Nebraska-Lincoln, Lincoln, NE, 68588, United States

1 - Deliver or Not? Optimal Revenue, Capacity, and Delivery Fee Policies for Future Drone-based Delivery Systems

Zhangchen Hu, UMASS Amherst, Amherst, MA, United States

Drones are expected to become a key component of commercial delivery services for retailers and courier companies. Using currently available retail data, we formulate a stochastic dynamic programming model to determine some optimal revenue, capacity, and delivery fee policies under uncertain demand for future drone-based delivery systems. Both analytical and numerical analyses are presented.

2 - On-demand Urban Aerial Mobility: Strategic Vertiport Network Design

Kai Wang, The Hong Kong Polytechnic University, Homantin, Kowloon, Hong Kong

Urban Aerial Mobility (UAM) will rely on a vertiport network—where eVTOL aircraft are operated. This paper optimizes the number, location, and capacity of vertiports while capturing the interdependencies between strategic vertiport deployment, tactical eVTOL operations, and customer adoption. This is cast as a nonlinear mixed integer model, including a queuing network of UAM operations and a robust optimization of customer adoption. We propose an iterative discretization algorithm to reformulate it as a second-order conic program. Results provide insights on future UAM systems in urban areas.

3 - Designing Mission Abort Strategies Based on Early-Warning Information: Application to UAV

Qiuzhuang Sun, National University of Singapore, Singapore, Singapore

An effective action to reduce the risk of casualties of unmanned aerial vehicles (UAVs) is the mission abort. This study designs the optimal mission abort policies based on information of early-warning signals that indicates possible forthcoming malfunction. Depending on the acquisition time of such information, operators may immediately abort the mission or ignore the information and continue the task. The optimal abort policy is obtained by carrying out an economic analysis. A case study on a UAV executing power-grid inspection missions is used to illustrate the applicability of the model.

■ SC52

CC- Skagit 1

Joint Session RMP/Practice Curated: Analytics in Online Platforms

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Daniela Saban, Stanford University, Palo Alto, CA, 94305, United States

Co-Chair: Kostas Bimpikis, Stanford University, Stanford, CA, 94305, United States

1 - First Delivery Gaps: a Supply Chain Lever to Reduce Product Returns in Online Retail

Divya Singhvi, MIT, 5010 A, 235 Albany Street, Cambridge, MA, 02139, United States, dsinghv@mit.edu, Georgia Perakis

We consider the problem of reducing product returns in online retail. Working with one of the largest fashion retailers of India, we perform an extensive observational data study, and an RCT to investigate the causal relationship of delivery gap and delivery promise on product returns. We estimate cost savings of as much as $1.5 million per year on account of reduced returns, due to faster deliveries. We then propose a data-driven delivery expediting framework that optimally balances delivery expediting costs with reverse logistics costs to minimize retailer's overall costs.

2 - Two-Sided Assortment Optimization

Ignacio Rios, Stanford University, Stanford, CA, 94305, United States, iriosu@stanford.edu, Daniela Saban, Fanyin Zheng

We study how assortments and history change users' behavior in a dating platform. We provide evidence that the assortment composition and the number of recent matches affect the probability that a given user is liked. Based on these results, we formulate the dynamic two-sided assortment optimization problem faced by the platform to decide the optimal assortment to offer to each user in each period, so as to maximize the number of matches. We show that the problem is NP-complete, and derive properties of the optimal solution in some special cases. We use these insights to propose simple heuristics and show that these can significantly improve the number of matches generated by the platform.

3 - Restaurant Delivery Platforms

Xuanming Su, University of Pennsylvania, The Wharton School, Philadelphia, PA, 19104, United States, xuanming@wharton.upenn.edu, Jaelynn Oh, Chloe Kim Glaeser

Restaurant delivery platforms have the potential to create value for customers, restaurants, and couriers. We analyze game-theoretic models to highlight best practices for all parties involved.

4 - understanding Customer Preferences: Labor Markets, Public Transport and Bike-share

Karan Girotra, Cornell Tech/Johnson Cornell University, New York, NY, 10044, United States, girotra@cornell.edu

I will present my experiences from estimating customer preferences in online labor marketplaces, ride-hailing services and bike-share systems. We will discuss the methodological developments and ways in which we have used these estimates to improve system performance.

■ SC53

CC- Skagit 2

Innovations in Pricing and Assortment Optimization

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Venus Lo, Cornell University, Ithaca, NY, 14853, United States

1 - The Exponomial Choice Model: Assortment Optimization and Data-driven Estimation Case Studies

Jacob Feldman, Olin Business School, Saint Louis, MO, 63108-1291, United States, jbfeldman@wustl.edu, Ali Aouad, Danny Segev

In this paper, we consider the yet-uncharted assortment optimization problem under the Exponomial choice model, where the objective is to determine the revenue maximizing set of products that should be offered to customers. Our main algorithmic contribution comes in the form of a fully polynomial-time approximation scheme (FPTAS), showing that the optimal expected revenue can be efficiently approached within any degree of accuracy. Furthermore, we conduct empirical evaluations of the Exponomial choice model. We present a number of estimation case studies using real-world data sets, spanning retail, online platforms, and transportation.

2 - Multi-stage and Multi-customer Assortment Optimization with Inventory Constraints

Elaheh Fata, Massachusetts Institute of Technology, Aeronautics and Astronautics, Cambridge, MA, 02139, United States, efata@mit.edu, Will Ma, David Simchi-Levi

We consider an assortment optimization problem where a customer chooses an item from a sequence of non-overlapping sets shown to her, while limited inventories constrain the items offered to a sequence of customers over time.In the special case where all of the assortments have size one, our problem captures the online stochastic matching with timeouts problem. For this problem, we derive a polynomial-time approximation algorithm which earns at least 1-ln(2-1/e), or 0.51, of the optimum. This improves upon the previous-best approximation ratio of 0.46, furthermore, we show that it is tight. For the general assortment problem, we establish the first constant-factor approximation ratio of 0.09.

3 - A Choice Modeling Framework for Service Time Windows

Xiao Lei, Columbia University, New York, NY, 10027, United States, xl2625@columbia.edu, Adam Elmachtoub

On-demand services have become increasingly common, and typically allow customers to choose a time window to receive the service. As a result, there is a natural trade-off between on-time customer service and operational cost. To address this issue, some service providers offer large time windows with rewards, together with the normal small ones. In this paper, we provide a choice modeling framework to address how customers choose among time windows, and apply this framework to evaluate various strategies for time window design.

4 - Omnichannel Assortment Optimization under the Multinomial Logit Model with a Features Tree

Venus Lo, Cornell University, Cornell University, Ithaca, NY, 14853, United States, vhl8@cornell.edu, Huseyin Topaloglu

We consider a retailer who sells online and in a physical store. Products are described by their features. A customer who purchases online can visit the physical store to try out products. Her preferences depend on the features of the products that she sees in the physical store's assortment. The retailer chooses an assortment to offer in-store to maximize total expected revenue from both stores. We organize products on a tree so that a leaf is a product. A non-leaf vertex is a feature common to leaves in its subtree. Assortment optimization is NP-hard and we present a FPTAS. Numerically, we show how we can approximate products with arbitrary combinations of features, and that our FPTAS performs well.

■ SC54

CC- Skagit 3

Mechanisms for Online Marketplaces

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Nikhil Garg, Menlo Park, CA, 94025, United States

1 - Driver Surge Pricing

Nikhil Garg, Stanford University, Stanford, CA, 94025, United States, nkgarg@stanford.edu, Hamid Nazerzadeh, Hamid Nazerzadeh

Ride-hailing marketplaces use dynamic pricing — surge — to balance the supply of available drivers with the demand for rides. We study pricing mechanisms for such marketplaces, from the perspective of drivers, and present the theoretical foundation that has informed the design of Uber's new additive driver-surge mechanism. We present a non-stationary stochastic model to capture the impact of surge pricing on driver earnings and their strategies to maximize earnings. We propose an incentive-compatible pricing mechanism for this environment. Even-though this mechanism can take a complicated form, we show that it is well-approximated by a additive-surge mechanism.

2 - A Pricing Framework for the Mobility Marketplace

Chamsi Hssaine, Cornell University, Ithaca, NY, 90025, United States, Siddhartha Banerjee, Ragavendran Gopalakrishnan, Samitha Samaranayake

The exploding popularity of ride-hailing services has led to a number of questions regarding the way they interact with other transportation modes. We study the design of an efficient mobility marketplace: a centralized platform where private firms and public transit can jointly offer hybrid multimodal trips to riders. We develop a framework for pricing such trips, with the objective of maximizing social welfare conditioned on every agent enjoying a weakly Pareto improving outcome compared to their status quo. We use our framework to propose two natural policies and show that these policies are Pareto improving, under a condition that captures a notion of the efficiency gains of multimodal transit.

3 - Consumer Reviews and Regulation: Evidence From NYC Restaurants

Chiara Farronato, Harvard Business School, Cambridge, MA, 02163, United States, Georgios Zervas

We study how hygiene cards and online reviews affect restaurant demand and hygiene. To extract signals of hygiene from reviews, we exploit the fact that health inspectors look for different types of violations to predict the occurrence of each violation from reviews. We find that reviews are more informative about food handling and pest violations than facilities and maintenance. We then estimate the effect of hygiene information from reviews on demand and restaurant hygiene. We find that demand is sensitive to signals of hygiene in reviews, and restaurants reviewed online are more likely to comply with hygiene standards for which reviews provide informative signals.

4 - Managing Market Mechanism Transitions: Evidence From a Field Experiment

Apostolos Filippas, Assistant Professor, Fordham University, New York, NY, 10012, United States, apostolosfilippas@gmail.com, Srikanth Jagabathula, Arun Sundararajan

We report on a field experiment conducted during a pricing mechanism change on a sharing economy platform. Providers who formerly set prices for their assets were assigned to groups with varying levels of pricing control. Even when faced with significantly higher revenues, providers retaliate against the mechanism change by exiting the platform, reducing asset availability, and cancelling transactions. Allowing providers to retain partial control lowered retaliation across all channels. We discuss "bring-to-market" costs and information asymmetry as explanations for our results.

■ SC55

CC- Skagit 4

Pricing under Quality Differentiation and Bundling

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Alexandre Jacquillat, Carnegie Mellon University, Pittsburgh, PA, 15213, United States

Co-Chair: Maxime Cohen, NYU Stern, New York, NY, 10012, United States

1 - Revisiting Bertrand Competition in the Face of Firm Asymmetry and Customer Heterogeneity

Haotian Song, NYU, New York, NY, United States, Maxime Cohen, Alexandre Jacquillat

Bertrand competition has been studied for over a century. It is a simple yet powerful game-theoretic model for price competition. In its basic form, customers are homogenous and are offered the same price. In many practical settings, however, firms cater to a heterogeneous mix of customers and can offer a different price to each customer segment. This paper extends our understanding of Bertrand competition by incorporating these two features. We convey that customer heterogeneity allows the firms to escape the Bertrand paradox, and that price discrimination is not necessarily beneficial.

2 - On-demand Service Sharing with Collective Dynamic Pricing

Mustafa Dogan, Carnegie Mellon University, Pittsburgh, PA, 15213, United States, mdogan@andrew.cmu.edu, Alexandre Jacquillat

We design a dynamic allocation and pricing mechanism for an on-demand platform that can serve customers individually, or together via sharing. We consider a setting with time-sensitive and heterogenous agents who arrive stochastically. The optimal policy features interdependencies across agents and over time. Nonetheless, it is governed by a simple index rule, based on the collective virtual value (CVV): as soon as the CVV exceeds a threshold, the platform serves all agents with a positive virtual value. Our findings highlight that, in the presence of sharing, time can be used as a discriminatory lever — in contrast with the classical results on dynamic pricing with commitment.

3 - Bundling under Price and Quantity Competition

Uday S. Karmarkar, LA Times Professor of Technology and Strategy, UCLA Anderson School of Management, Los Angeles, CA, United States, ukarmark@anderson.ucla.edu, Araz Khodabakhshian, Guillaume Roels

Bundling is the offering of a combination of products and services, usually in fixed proportions, for a single price. We address bundling strategy under competition, which has received limited attention in the past. We consider price competition in a Bertrand duopoly with both independent and bundled components, and quantity competition in a Cournot oligopoly with entry costs. In general, bundling is a successful strategy, though independent component suppliers can survive.

4 - Revenue Management with Bundles

Tarek Abdallah, Northwestern University, Evanston, IL, United States, tarek.abdallah@kellogg.northwestern.edu, Arash Asadpour, Joshua Reed

We study the optimal dynamic bundling and pricing problem when a multi-item firm has limited inventory and a finite selling horizon. We model the problem as a classical network revenue management problem where the resources are the items and the products are the different possible bundles. The standard fluid regime for this problem is intractable due to the exponential number of bundles. We analyze the problem by scaling different model parameters to capture different market dynamics. More interestingly, for some of these regimes we show that the limiting problem is tractable and we can provide closed form asymptotically optimal solutions.

5 - Pricing with Fairness

Xiao Lei, Columbia University, New York, NY, 10025, United States, Maxime Cohen, Adam Elmachtoub

While discriminative pricing has become common, regulators often aim to impose fairness. We consider the problem of pricing with fairness constraints. We first propose four definitions: fairness in (1) price, (2) demand, (3) surplus, and (4) no-purchase valuation. We then analyze the pricing strategy of the seller, and the impact of fairness. Under a linear demand, we show that imposing some fairness in price or no-purchase valuation increases social welfare, whereas fairness in surplus or demand are always detrimental. A similar pattern is also observed for other common demand models.

■ SC56

CC- Skagit 5

Revenue Management with Online Learning

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Yiwei Chen

1 - Dynamic Learning and Market Making in Spread Betting Markets with Informed Bettors

Yifan Feng, University of Chicago, Chicago, IL, United States, yfeng4@chicagobooth.edu, John R. Birge, N. Bora Keskin, Adam Schultz

The spread betting market is a prevalent form of prediction market, where participants bet on whether the outcome of a future event exceeds a certain spread line. We study how the market maker should move the spread line dynamically to maximize profit. Anonymous bettors with heterogeneous strategic behavior and information levels participate in the market. The non-omnipotent market maker strives to extract information from the market while guarding against the strategic manipulation of an informed bettor.

2 - A Dimension-free Algorithm for the Contextual Continuum-armed Bandit Problem

Ningyuan Chen, University of Toronto, Clear Water Bay, Toronto, ON, Canada, Jeff Hong, Wenhao Li

In multi-armed bandit problems, when the contextual information and the decision variable are both continuous and high-dimensional, it is known that the optimal rate of regret scales exponentially with both dimensions. In this project, we show that when the objective function is globally concave in the decision variable, we can alleviate the curse of dimensionality.

3 - Learning Non-parametric Contextual Demand Curves in Repeated Auctions

Jason Cheuk Nam Liang, Massachusetts Institute of Technology, Cambridge,, MA, United States, Negin Golrezaei, Patrick Jaillet

We study dynamic pricing for repeated contextual second-price auctions facing strategic buyers who aim to maximize their long-term discounted utility. The seller has limited information about buyer demand, which depends on context vectors for auctioned items and a non-parametric noise distribution that captures buyers' idiosyncratic taste. We propose a policy robust to buyers' strategic (corrupted) bids, which sets contextual reserve prices to maximize seller's revenue. Our policy controls the number of periods during which buyers significantly corrupt bids, and achieves a T-period regret of $O(\sqrt{dT})$ against a clairvoyant policy that has full information of the buyers demand.

4 - Network Revenue Management with Online Inverse Batch Gradient Descent Method

Yiwei Chen, University of Cincinnati, Cincinnati, OH, 45206, United States, Cong Shi

We study a family of price-based network revenue management problems in which the revenue rate is concave in market shares. The firm does not know the demand function in advance and must learn it over time. We propose an online inverse batch gradient descent algorithm. It proceeds in batches. In each batch, the firm posts a series of prices perturbed around a reference price. The firm uses the sales data under these prices to estimate market shares. The firm then carries out a stochastic gradient descent step in the market share space to get a new reference price for the next batch. We establish an upper bound on the regret of this algorithm that is independent of the number of products or resources.

■ SC57

CC- Yakima 1

Joint Session PSOR/Practice Curated: Decision Analytic Models for Public Health

Sponsored: Public Sector OR

Sponsored Session

Chair: Nidhi Khurana, CDC, Atlanta, GA, 30333, United States

1 - Impact of Targeting Pre-exposure Prophylaxis to Individual Transmission Groups in the United States

Nidhi Khurana, CDC, Atlanta, GA, 30333, United States, kqt3@cdc.gov, Paul G. Farnham, Katherine A. Hicks, Justin Carrico, Stephanie Sansom

We used a dynamic, compartmental model of the sexually active U.S population to estimate the impact of delivering pre-exposure prophylaxis (PrEP) to persons at high risk of acquiring HIV in individual transmission groups (men who have sex with men, persons who inject drugs, heterosexual males, and heterosexual females). In alternative scenarios, we modeled the application of PrEP to high-risk persons in each transmission group, and we assessed the number of infections averted across all transmission groups, the number of people on PrEP per infection averted, and the total cost incurred from 2020 through 2024.

2 - Modeling the Future of HIV in Turkey: Disease and Cost Implications of Improving Diagnosis and Treatment

Emine Yaylali, Assistant Professor, Istanbul Technical University, 2995 Rosebrook Drive, Istanbul, 30033-3822, Turkey, emineyaylali@itu.edu.tr, Melisa Erdogan

There were 17,884 cases of HIV infection reported until the end of 2017 in Turkey. Although the prevalence rate of Turkey could be considered as low (0.1 - 0.3%), the number of diagnosed HIV cases in the last five years has been tripled with a particularly high rate of infection for men who have sex with men (MSM). We developed a dynamic compartmental model of HIV transmission and progression in Turkey to determine HIV incidence and prevalence, to assess current continuum of care and to analyze the disease burden of cost of two scenarios: (i) keep status quo and (ii) improve diagnosis and treatment of HIV.

3 - Cost-effectiveness of Pre-exposure Prophylaxis and HIV Testing Strategies in India

Pooyan Kazemian, Harvard Medical School, Boston, MA, 02114, United States, pooyan.kazemian@mgh.harvard.edu, Sydney Costantini, Rochelle P. Walensky, Kenneth A. Freedberg

Using a detailed microsimulation model of HIV disease, we developed a novel method to incorporate the indirect community benefit of pre-exposure prophylaxis (PrEP) into incremental cost-effectiveness ratios for cost-effectiveness analysis. We assessed clinical and economic outcomes as well as the budget impact of various PrEP and HIV testing strategies for men who have sex with men in India.

4 - A Reinforcement Learning Algorithm to Inform Optimal Policy for Eliminating HIV in the U.S.

Seyedeh Nazanin Khatami, University of Massachusetts-Amherst, Amherst, MA, 01002, United States, skhatami@umass.edu, Chaitra Gopalappa

We address the question of how to reduce new HIV incidences close to zero in the US by formulating the problem as a Markov decision process with decision-making steps at 5-year intervals over a finite time period, and solved using a reinforcement learning algorithm. The objective of the model is to identify an intervention strategy that maximizes the expected total reward, the difference in the total quality-adjusted life-years saved multiplied with the gross domestic product per capita in the US and the associated costs of the strategy for heterosexuals, men who have sex with men, and persons who inject drugs.

5 - Assessing the Benefits of Reducing HIV Diagnosis Delay and Increasing Adherence to HIV Treatment

Nidhi Khurana, CDC, Atlanta, GA, United States, Evin Jacobson, Zihao Li, Paul Farnham, Stephanie Sansom

We used an agent-based simulation model to follow for 20 years a representative cohort of persons infected with HIV in the year 2015. We assessed the benefits of diagnosing HIV early and taking HIV antiretroviral therapy (ART) as prescribed on the percentage of persons surviving 20 years after infection and their average annual HIV transmission rate. Persons living with HIV or at risk of acquiring it can enhance their survival and greatly reduce their risk of sexual transmission to partners by frequent testing for HIV and, among those diagnosed with HIV, adhering to ART.

■ SC58

CC- Yakima 2

Immigration Policy

Emerging Topic: Policy & Government

Emerging Topic Session

Chair: Nick Arnosti

1 - Snapshot Models of Undocumented Immigration

Edward H. Kaplan, Beach Professor of Operations Research, Yale University, Yale School of Management, Box 208200, New Haven, CT, 06520-8200, United States, Scott Rodilitz

The Mexican Migration Project samples undocumented Mexican immigrants to the United States after their return to Mexico. We focus on sampled migrants' most recent trip to the United States. Such data are subject to an extreme physical bias: to be included in the sample, migrants must have returned to Mexico by the time of the survey. Our analysis distinguishes between solitary and repeat (circular) migrants, and allows "retirement" from circular migration. We show that migrants remain in the US much longer than previously estimated, and produce lower bounds on the total number of undocumented immigrants that exceed conventional estimates based on US-based census-linked surveys.

2 - Is Ice Enforcing the Law? A Machine Learning Approach

Mohammad Fazel-Zarandi, Massachusetts Institute of Technology, Cambridge, MA, 06510, United States, fazel@mit.edu, Dimitris Bertsimas

In this work, we use individual-level administrative data from the immigration and customs enforcement (ICE) and the state of the art interpretable machine learning tools to answer the following questions: Does the data support ICE's claim of prioritizing deportations based on severity of crimes? Given a significant change in policy in 2014, is the new policy more effective in aligning ICE's prioritization objective to how the policy is actually enforced by ICE offices across the US? This work is a first step in our overall aspiration to use interpretable machine learning tools and large data to analyze and improve public policy for significant societal challenges.

3 - Dynamic Management of Local Community Capacity for Refugee Resettlement

Narges Ahani, Worcester Polytechnic Institute, Worcester, MA, United States, nahani@wpi.edu, Andrew C. Trapp, Alexander Teytelboym, Alessandro Martinello, Tommy Andersson

Local communities in the US voluntarily resettle refugees, and government-approved capacities are set every September. However, refugees arrive stochastically over the year. Resettlement agencies must ensure that they neither overshoot nor undershoot approved capacities by the close of the fiscal year. As local communities provide heterogeneous integration services to refugees, the greedy placement decisions they currently make could result in inefficient use of resettlement capacity, and lower refugee welfare. We model the stochastic nature of US refugee arrivals using historical data to dynamically inform capacity estimates, thereby improving the performance of placement decisions.

4 - Visa Lottery Design

Nick Arnosti, Columbia Business School, New York, NY, 10027, United States

Lotteries play an important role in determining which visa applicants are accepted. Many existing lotteries include multiple categories of visas, targeted to distinct but overlapping populations. We study several ways to accommodate these targeting criteria, and analyze the ways in which they differ. We use our results to discuss recent changes in the H1B lottery procedure.

■ SC58a

CC- Chelan 1

1:30-2:15 Optimization Direct / 2:15-3:00 MyEducator

Vendor Tutorials

1 - A DOCplex and ODH|CPLEX Python primer

Alkis Vazacopoulos, Optimization Direct, Inc., Harrington Park, NJ, 07640, United States

This short tutorial shows participants how to build a basic model using the DOCplex API in Python. This session includes setting the Python environment, reading data from a csv or spreadsheet, creating variables, objective functions, constraints, solving the model, and returning the results. Additionally this session points the participants to further reading so that they may expand their capabilities. Furthermore we will present the brand new ODH|CPLEX API for Python, which improves solution times for large models.

2 - This is the Future of Education!

Scotty Pectol, MyEducator, Orem, UT, United States, Jaret Wilson

This is the future of education! An affordable alternative to OER with up-to-date content from world-class author teams. Created by professors for professors, MyEducator smart interactive textbooks and learning resources are ideal for any classroom setting. Our approach enhances student engagement, improves learning outcomes, instructors receive better teaching evaluations, and students have more fun in the classroom. Each smart learning resources is hosted on our intuitive platform with auto-graded assessments, ample instructor material, robust analytics, all with seamless single sign-on LMS integration, low student cost, lifetime access, and best-in-class service. Full access will be given to any book on our platform to attendees.

■ SC59

CC- Chelan 2

Student Interaction Session & Poster Competition Session

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Dongping Du, Texas Tech University, Lubbock, TX, 79409, United States

Co-Chair: Ying Lin, University of Houston, Houston, TX, 77204, United States

1 - Student Introduction and Interaction Session & Best Student Poster Competition

Dongping Du, Texas Tech University, Lubbock, TX, 79409, United States, dongping.du@ttu.edu, Ying Lin

The Student Interaction Session is designed for QSR student to build their professional network, show up their talents, and learn from invited guests. The session consists of students' introduction, student and guest interactions, and Best Student Poster Competition. Each participant will have 2 minutes to deliver an elevator speech about his/her research interests and accomplishments; Senior QSR members and guests will be invited to interact with attendees and share experience; A panel of judges will select a poster competition winner, which will be announced at the QSR business meeting.

2 - Student Introduction & Interaction Session & Best Student Poster Competition

Ying Lin, University of Houston, Houston, TX, 77204, United States

The Student Introduction and Interaction Session & Best Student Poster Competition session is designed for QSR student to build their professional network, show up their talents, and learn from invited guests. The session consists of students' introduction, student and guest interactions, and Best Student Poster Competition. Each participant will have 2 minutes to deliver an elevator speech about his/her research interests and accomplishments; Senior QSR members and guests will be invited to interact with attendees and share experience; A panel of judges will select a poster competition winner, which will be announced at the QSR business meeting.

■ SC59a

CC- Chelan 3

IOS Award Presentations

Award Session

Chair: Daniel Bienstock, Columbia University, Dept of IEOR, 342 Mudd, New York, NY, 10027, United States

1 - IOS Award Presentations

Daniel Bienstock, Columbia University, Dept of IEOR, New York, NY, 10027, United States, derdano@gmail.com

The session description: IOS presents four awards annually. The recipients of these prizes will present their award-winning works.

■ SC60

CC- Chelan 4

Technometrics Invited Session

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Daniel Apley, Northwestern University, Evanston, IL, United States

1 - Analysis-of-marginal-tail-means (ATM): A Robust Method for Discrete Black-box Optimization

Simon Mak, Duke University, Durham, NC, 30308, United States, C.F. Jeff Wu

We present a new method, called Analysis-of-marginal-Tail-Means (ATM), for effective robust optimization of discrete black-box problems. One weakness of existing methods is that they are not robust: these methods perform well under certain assumptions, but yield poor results when such assumptions (which are difficult to verify in black-box problems) are violated. ATM addresses this by combining both rank- and model-based optimization, via the use of marginal tail means. We demonstrate the effectiveness of ATM in two real-world problems: the first on robust parameter design of a circular piston, and the second on product family design of a thermistor network.

2 - A Decomposition of Total Variation Depth for Understanding Functional Outliers

Huang Huang, National Center for Atmospheric Research, Boulder, CO, United States, huang.huang@kaust.edu.sa, Ying Sun

There has been extensive work on data depth-based methods for robust multivariate data analysis. Recent developments have moved to functional data. We propose a notion of depth, the total variation depth, for functional data, which has desirable features and is suited for outlier detection. We show that the novel formation of the total variation depth leads to useful decomposition associated with shape and magnitude outlyingness of functional data. Compared to magnitude outliers, shape outliers are often masked among the rest of samples and more difficult to identify. We then further develop an effective procedure and visualization tools for detecting both types of outliers.

3 - Controlling Sources of Inaccuracy in Stochastic Kriging

Wenjia Wang, SAMSI, Durham, NC, United States, wenjia.wang234@duke.edu, Benjamin Haaland

Scientists and engineers commonly use simulation models to study real systems. For expensive simulations, stochastic kriging is commonly used to generate predictions for simulation model outputs subject to uncertainty due to function approximation and stochastic variation. We develop and justify a few guidelines for experimental design, which ensure accuracy of stochastic kriging emulators. We decompose error in stochastic kriging predictions into four components and provide means to control each in terms of properties of the experimental design. The design properties implied for each source of error are weakly conflicting and broad principles are proposed. A few examples are presented.

■ SC61

CC- Chelan 5

Journal of Quality Technology

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Bianca Maria Colosimo, Politecnico di Milano, Politecnico di Milano, Milan, I-20156, Italy

1 - A Spatial-adaptive Sampling Procedure for Online Monitoring of Big Data Streams

Andi Wang, Georgia Tech, Atlanta, GA, United States, andi.wang@gatech.edu, Xiaochen Xian, Kaibo Liu, Fugee Tsung

This presentation proposes a Spatial Adaptive Sampling and Monitoring (SASAM) procedure to detect shifts occurred in big data streams when (1) only partial information can be observed at each time, and (2) out-of-control (OC) variables are clustered in a small and unknown region. This procedure integrates two ideas to leverage the spatial information of data streams: (1) random sampling that searches for possible OC variables; and (2) directional sampling that focuses on OC variables clustered in a suspicious region. Simulation and real example show that the proposed method significantly outperforms the existing method without taking the spatial information into consideration.

2 - Change Detection in a Dynamic Stream of Attributed Networks

Mostafa Reisi Gahrooei, University of Florida, Gainesville, FL, United States

We propose a methodology for monitoring a stream of attributed networks. In order to model both structural and temporal behavior of a sequence of networks, we integrate generalized linear model with state space modeling. This model is used along with an Exponentially Weighted Moving Average (EWMA) control chart for quick detection of abrupt changes. We tested our proposed approach in two real-world data sets.

3 - Pareto Optimization of an Injection Molding Process using a Sequential Design for a Combined Simulator and Physical Experiment

Thomas Santner, Professor, Ohio State University, Columbus, OH, 43210, United States, santner.1@osu.edu, Angela Dean, Allen Po-Hsu Chen, Maria Villarreal-Marroquın, Rachma Mulyana, Jose M. Castro

This talk will describe a sequential method for identifying the settings of control variables to Pareto optimize multiple characteristics of a manufactured product. The methodology is based on experiments that combine the output from physical and simulator platforms. The method is described in an application that selects the settings of an injection molding machine to minimize component shrinkages when both a deterministic computer simulator of the injection molding machine is available as well as runs on the molding machine itself. The method is based on a Bayesian calibrated predictor of the mean of the physical system and an expected improvement criterion.

4 - JQT Highlights – The New Sections on Data and Software

Bianca Maria Colosimo, Professor, Politecnico di Milano, Via La Masa, 1, Milan, I-20156, Italy, biancamaria.colosimo@polimi.it

JQT has recently revised the Case Study Section and introduced a new JQT Software Section. In this presentation, we will introduce these revised/new Departments of the Journal, in order to encourage new submissions in these areas.

■ SC62

CC- Tahoma 1

Advances in Healthcare Analytics

Sponsored: Health Applications

Sponsored Session

Chair: Van-Ahn Truong

1 - Simultaneous Offering under Rational Inattention

Ronghuo Zheng, University of Texas at Austin, Austin, TX, United States, Tinglong Dai

In the US, when an organ from a deceased donor becomes available, an organ procurement organizations (OPO) will offer the organ to multiple transplant centers using an online, automated offering system called DonorNet. Surgeons conduct research into the details of the offer and decide whether to accept or reject it. Ultimately, the organ is offered to the patient with the highest priority first, then second highest priority, and so on. In this study, motivated by an OPO's problem of determining the optimal number of simultaneous offers, we model the strategic interaction among transplant centers both within and across batches, leading to structural properties and computational insights.

2 - Should Returning Customers Be Prioritized in Booking an Appointment?

Yichuan Ding, University of British Columbia, Vancouver, BC, Canada, daniel.ding@sauder.ubc.ca, Diwakar Gupta, Xiaoxu Tang

We study how to manage returning customers in an appointment-based slotted-service queue with the goal of maximizing service volume. Returning customers prefer to be served by the same server that they visited in their previous visit. We consider a simple strategy that a service provider may use to reduce balking among returning customers designate some returning customers as high-priority customers. We show that with limited waiting-room, a service system should not prioritize some returning customers in order to maximize the throughput rate. However, it is always optimal to prioritize some customers in the system when there is no limit on the waiting room.

3 - Data-driven Stochastic Optimization Approaches to Determine Decision Thresholds for Risk Estimation Models

Gian-Gabriel P. Garcia, University of Michigan, Ann Arbor, MI, United States, garciagg@umich.edu, Mariel Sofia Lavieri, Ruiwei Jiang, Thomas McAllister, Michael McCrea, Steven Broglio

The growing availability of data has popularized risk estimation models in healthcare. Yet, utilizing these models for accurate diagnosis decisions is challenging. We formulate the two-threshold problem (TTP) as a stochastic program to determine when a risk estimation model can accurately make a positive or negative diagnosis, or if the model is inconclusive. We characterize the optimal solution to TTP using a related linear program (TTP*) and derive additional frameworks for which our analytical results hold. We solve TTP* using quantile estimation and distributionally robust optimization, then apply TTP* to concussion assessment data where we find that it outperforms traditional methods.

4 - Learning to Rank under Evolving Customer Reviews

Jingtong Zhao, Columbia University, New York, NY, United States, jz2477@columbia.edu, Van-Anh Truong, Zhen Xu, Jie Song, Xin Pan

In many electronic healthcare platforms, patients are encouraged to leave reviews. Subsequent patients and the platforms make use of the information to infer the quality of the physicians. An important service provided by a platform is the recommendation of physicians that best meet patients' care criteria. We study how a platform can learn from patient reviews, as well as the way that they make subjective choices when presented with such recommendations. We provide an algorithm to learn from data and to make personalized recommendations to patients. The objective is to maximize patients' long-term satisfaction. We use the notion of regret to evaluate the algorithm's performance.

■ SC63

CC- Tahoma 2

Pierskalla Award Finalists

Sponsored: Health Applications

Sponsored Session

Chair: Jonathan Helm, Indiana University, Bloomington, IN, 47401, United States

Co-Chair: Pengyi Shi, Purdue University, West Lafayette, IN, 47907, United States

1 - Adaptive Clinical Trial Designs with Surrogates: When Should We Bother?

Arielle Elissa Anderer, The Wharton School, Wynnewood, PA, 19096, United States, Hamsa Bastani, John Silberholz

Surrogate outcomes have long been used in clinical trials when the true outcome of interest is expensive, time consuming, or otherwise difficult to measure. In this work we propose optimal adaptive clinical trial designs that integrate surrogate and true outcomes, and we analytically and empirically characterize regimes where our designs are especially beneficial.

2 - How Do Tumor Cytogenetics Inform Cancer Treatments? Dynamic Risk Stratification and Precision Medicine Using Multi-armed Bandits

Zhijin Zhou, University of Washington, University of Washington, Foster School of Business, Seattle, WA, 98195, United States, Yingfei Wang, Hamed Mamani, David G. Coffey

This work presents a data-driven approach to develop personalized treatment strategies for multiple myeloma patients. Using fine-grained clinical dataset, we first develop a Hidden Markov model to understand patients' treatment responses, we then formulate the treatment recommendation problem as a Bayesian contextual bandit by considering patient disease dynamics and cytogenetic variants. Compared with other benchmark strategies, our method results in the best overall survival outcomes, with higher improvement for aging or high-risk patients with more complications.

3 - An Achievable-Region-Based Approach for Kidney Allocation Policy Design with Endogenous Patient Choice

Yichuan Ding, McGill University, University of British Columbia, 6333 Larkin Drive, Montreal, QC, V6T 1C3, Canada, Baris Ata, Stefanos Zenios

We seek kidney allocation policies considering patients' strategic choices. We analytically prove that it suffices to use priority scores affine in the patient's waiting time, and numerically show that life years can be increased by allowing patient rankings to depend on kidney quality. Consequently, the policy change in 2014, that implemented prioritizing the healthiest patients when allocating the highest 20% quality organs, is a step towards the right direction. Nevertheless, further improvements can be achieved by also prioritizing the least healthy patients for the lowest-quality organs.

4 - Design of Incentive Programs for Optimal Medication Adherence

Joel Goh, NUS Business School, Mochtar Riady Building, 15 Kent Ridge Drive, 08-04, Singapore, 119245, Singapore, Sze-chuan Suen, Diana Maria Negoescu

We consider how to design a schedule of incentive payments to induce optimal treatment adherence levels with heterogeneous patient preferences for adherence. A unique challenge in this problem is that any prior commitment that a patient makes to a given level of treatment adherence cannot be contracted upon, rendering existing contract-theoretic approaches ineffective. We develop new models and analyses to capture this feature and conduct a numerical study using representative data in the context of the tuberculosis epidemic in India.

■ SC64

CC- Tahoma 3

Drug Shortages

Sponsored: Health Applications

Sponsored Session

Chair: Emily L. Tucker, University of Michigan, Ann Arbor, MI, 48109, United States

1 - Analysis of Supply Volatility in U.S. Antibiotics Drug Shortages (2010-2016)

Rozhin Doroudi, Northeastern University, Boston, MA, United States, doroudi.r@husky.neu.edu, Ozlem Ergun

A more comprehensive view of the entire supply chain, employing a data-driven approach has the potential to strengthen the ability of the FDA, or other supply chain stakeholders, to proactively anticipate and respond to drug shortages.Using IQVIA's comprehensive data on US drug supply chain, we aim to study network structure of the supply chain and analyze supply volatility of products.

2 - Analyzing Disruption Patterns in Pharmaceutical Supply Chains

Jackie Griffin, Northeastern University, Boston, MA, United States, ja.griffin@northeastern.edu, Rana Azghandi

Pharmaceutical supply chains are vulnerable to various disruptions. Closer investigation of this type of supply chain reveals that the risk of disruptions is usually inevitable. Meanwhile, traditional supply chain models fail to recover from these disruptions in a reasonable time objective. In this research, we aim to predict recall disruptions as a mitigation effort. By using pattern recognition methods based on recall data we develop a sophisticated disruption model to help decision-makers to anticipate the risk in the supply chain in the future.

3 - Mitigating Drug Shortages: Should Hospitals Use Their Own Drug Manufacturer?

Hongmei Sun, Ivey Business School, Western University, London, ON, Canada, hsun.phd@ivey.ca, Gregory S. Zaric, Hubert Pun

Drug shortages are a problem in many countries. Some US hospitals established a drug company to manufacture certain medicines in order to mitigate shortage. Our goal is to investigate under what circumstances a hospital will benefit from owning an inhouse manufacturer. We construct a game theoretic model to study the interaction between a hospital and an outside manufacturer. The hospital could procure a drug either from an inhouse producer or from the outside manufacturer whose production has a random yield which can cause a drug shortage. The hospital also has a chance to make emergency production. Our study reveals the hospital's optimal production plan under different combination of parameters.

4 - Modelling & Analysis of Drug Shortages in Europe

Vincent Hargaden, University College Dublin, School of Mechanical & Materials Engineering, Engineering & Materials Science Centre, Belfield, D04 V1W8, Ireland, vincent.hargaden@ucd.ie

Based on the research carried out in a European wide project (COST Action 15105 - European Medicines Shortages Research Network), we develop system modelling approach in five European countries with the goal of reducing the impact of hospital based drug shortages.

5 - Pharmaceutical Supply Chain Resiliency and Drug Shortages

Emily L. Tucker, University of Michigan, Ann Arbor, MI, United States, eltuck@umich.edu, Mark S. Daskin, Burgunda V. Sweet, Wallace J. Hopp

Shortages of medically-necessary drugs continue to occur in the United States. Each shortage lasts for over a year on average and can have substantial effects on health system costs and patient care. The highly-regulated industry has limited ability to adapt once a shortage occurs, and strategic resiliency decisions are highly influential on a company's ability to meet demand after supply shocks. We present a model of resiliency decisions for a pharmaceutical supply chain and analyze market conditions that may contribute to shortages. We discuss the effects of competition.

■ SC65

CC- Tahoma 4

HAS Distinguished Speakers – II

Sponsored: Health Applications

Sponsored Session

Chair: Mark P. Van Oyen, University of Michigan, Ann Arbor, MI, United States

Chair: Hui Zhao, The Pennsylvania State University, Smeal College of Business, University Park, PA, United States

1 - Machine Learning and Personalized Healthcare

Mohsen Bayati, Associate Professor, Stanford University, 655 Knight Way, E363, Stanford, CA, 94305, United States

Over the last decade, there has been a surge in application of machine learning methods in healthcare. In this talk, we will discuss a few examples of these applications as well as some of the methodological challenges going forward.

2 - Public Health Screening: Models, Algorithms, and Policies

Ebru Korular Bish, Associate Professor, Virginia Tech, Dept Ind/Sys Eng, Blacksburg, VA, 24061-0118, United States, ebru@vt.edu

Screening for diseases is an important, and extensively used, public health tool; early detection can improve clinical outcomes and reduce the spread of the disease, especially for diseases that have slow to develop and/or initially non-specific symptoms (e.g., Babesiosis, Zika, hepatitis, cystic fibrosis). A major challenge is to design public health screening policies that can accurately classify a large number of subjects, having different risk factors, with limited resources and imperfect tests. I will present an overview of this research area, discuss several key models to optimize resource allocation in public health screening, and highlight the challenges and opportunities.

■ SC66

CC- Tahoma 5

Patient Scheduling: New Models and Innovative Applications

Sponsored: Health Applications

Sponsored Session

Chair: Nan Liu, Boston College, Chestnut Hill, MA, 02467, United States

1 - Breaking the Post-anesthesia Bottleneck in Perioperative Care

John Lyons, Western University-Ivey Business School, 23 Pine Ridge Drive, London, ON, N5 X. 3G7, Canada, jlyons@ivey.ca, Mehmet A. Begen, Peter Bell

We schedule surgeries in multiple operating rooms (ORs) feeding a single post anesthesia care unit (PACU) with limited bed capacity where most (90%+) patients need to recover. If the PACU is full, a patient cannot leave the OR, and subsequent surgery in that OR may be delayed/cancelled. We develop a scheduling framework that allows a central planner to sequence surgeries to avoid PACU patient load surges, and to highlight direct and cascading impacts of ward unit bed unavailability and PACU holds on OR delays. We are working with a large regional tertiary care hospital to test and further refine our model as an aid to improve throughput and reduce elective surgery backlog.

2 - How to Manage Doctor Appointments with a Shared Medical Appointment Option

Nazli Sonmez, London Business School, Regent's Park, London, NW1SN, United Kingdom, nsonmez@london.edu, Kamalini Ramdas, Sarang Deo

Shared medical appointments are an alternative to traditional one-on-one appointments for routine care of chronic diseases that offer an innovative, interactive approach to healthcare delivery. They are not widely used even though there is a high potential. To adopt this new healthcare delivery method, the service providers must make an upfront decision on how to allocate service capacity. We develop a model that will incorporate what we learn about how patients make trade-offs while choosing an appointment, when offered two different appointment types using the data from a healthcare provider. This model will provide insight into how many appointments from each type need to be scheduled.

3 - Multi-priority Multi-class Advance Patients Scheduling

Yan Liang, University of Toronto, Toronto, ON, Canada, yan.liang@rotman.utoronto.ca, Hossein Abouee Mehrizi, Opher Baron, Oded Berman

In this paper, we study an advanced scheduling problem. Patients are from multiple service types with multiple priority classes. The service time is deterministic for each service type. Different priority classes have different wait time targets to patients. Each patient can be scheduled to any day within the booking horizon or be diverted to other providers at a higher cost.

4 - Dynamic Inter-day and Intra-day Appointment Scheduling

Christos Zacharias, University of Miami, Coral Gables, FL, 33146, United States, czacharias@bus.miami.edu

The simultaneous consideration of appointment day (inter-day) and time of day (intra-day) in dynamic scheduling decisions has not been addressed adequately in the Operations Research literature due to its large dimensionality and computational complexity. The scope of this research is to provide an optimization platform that solves this problem effectively and efficiently. We leverage the multimodularity property of the static intra-day problem and its propagation through dynamic programming recursion.

5 - On Scheduling Appointments in Tandem Service Systems

Nan Liu, Boston College, Chestnut Hill, MA, 02467, United States, nan.liu@bc.edu, Guohua Wan, Shan Wang

In many healthcare settings, patients come for a series of services instead of a single one. Each of these service stages may require a substantial amount of time with significant variability. For instance, in an infusion center, patients usually go through three main stages of services—blood draw, physician exam (to finalize/verify the treatment plan), and finally, infusion; in an orthopedic clinic, a common care path involves an X-ray exam, followed by a physician consultation, and finally, the service by orthopedic technicians. We study how to manage appointment scheduling in such tandem service systems.

■ SC68

S- University

Hub Location

Sponsored: Location Analysis

Sponsored Session

Chair: Sibel Alumur Alev, University of Waterloo, Waterloo, ON, N2L 3G1, Canada

1 - Hub Location and Route Dimensioning: Strategic and Tactical Intermodal Transportation Hub Network Design

Baris Yildiz, Asst. Prof., Koc University, Koc University IE Department, Rumelifeneri Yolu, Istanbul, Turkey, Hande Yaman, Oya Ekin Karasan

We propose a novel hub location model which does not make any assumptions on the structure of the network and on the discount due to economies of scale. Our model extends the literature in three dimensions: (1) instead of connecting non hub nodes directly to hub nodes, we consider routes that visit several non-hub nodes and carry their traffic to the their associated hub and back, (2) instead of connecting pairs of hubs directly, we design routes that can visit several hub nodes, (3) vehicle types and quantities are optimized concurrently with the network design. An efficient branch and cut algorithm is developed to solve realistic size problem instances.

2 - Hub Location under Congestion and Capacity Considerations

Vedat Bayram, TED University, No: 48, Ankara, 06420, Turkey, vedat.bayram@tedu.edu.tr, Baris Yildiz, Mohammad Saleh Farham

In this study, the effect of congestion on the number, location and the capacity of hubs is analyzed and policies that simultaneously minimize the cost of installing hubs, building capacities and transportation, and the effect of congestion is developed. We model the congestion effect by presenting a novel path based formulation of the hub location problem, which enables us to determine the optimal number, locations and capacities of hubs considering the tradeoff between the cost and the congestion effect. We use large scale optimization methodologies such as Benders decomposition, column generation and second order cone programming to solve the problem efficiently.

3 - Two Formulations for a Profit Maximizing Hub Location Problem with Hub Congestion, Time-sensitive Demands and 1-stop Paths

Armin Lüer-Villagra, Universidad Andres Bello, Santiago, Chile, armin.luer@unab.cl, Elena Fernández

Hub-and-spoke network topology is commonly used if it is reasonable to consolidate flows at intermediate facilities. Hub location models have been used to design such networks, and have been extended to consider hub congestion, time-sensitive demands, competitive settings, etc. We study a problem where a profit-maximizing company wants to design a hub-and-spoke network with p hubs. The demand is sensitive to total travel time, and hubs processing times depends on inbound flow. We consider that every path includes at most one hub. We propose two formulations and different procedures to solve instances up to 50 nodes.

4 - Robust-stochastic Models for Profit Maximizing Hub Location Problems

Sibel A. Alumur, University of Waterloo, Waterloo, ON, N2L 3G1, Canada, sibel.alumur@uwaterloo.ca, Gita Taherkhani, Seyed Mojtaba Hosseini

We introduce robust-stochastic models for profit maximizing hub location problems simultaneously incorporating two different types of uncertainty. Initially, a two-stage stochastic program is presented for the stochastic demand. Robust optimization techniques, including both interval uncertainty and discrete scenarios, are used to incorporate uncertain revenues into the stochastic problem. Robust-stochastic models with a max-min criterion and a min-max regret objective are then formulated. Exact algorithms based on Benders decomposition coupled with sample average approximation scheme are developed and enhanced by novel acceleration techniques.

■ SC69

S- Seneca

Joint Session MSOM/HC/Practice Curated: Empirical Health Care Operations

Sponsored: Manufacturing & Service Oper. Mgmt/Healthcare Operations

Sponsored Session

Chair: Hummy Song, Philadelphia, PA, 19104, United States

1 - Recovering from Critical Incidents: Evidence from Paramedic Performance

Jonas Oddur Jonasson, MIT Sloan School of Management, Cambridge, MA, 02142, United States, joj@mit.edu, Hessam Bavafa

We examine operational performance in settings where workers can encounter critical incidents (CIs)—jobs which are sufficiently disturbing to challenge workers' coping mechanisms. Using data on 902,002 ambulance activations we find that Crews who have encountered one prior CI (two prior CIs) spend on average 2.6% (7.5%) more time completing each remaining ambulance activation in the shift. The largest effects come from the sub-processes which are least standardized and where paramedics cannot rely on standard operating procedures.

2 - Improving MRI Hospital Waiting Times Using Geographical Partial Pooling: An Empirical Analysis of 72 Hospitals in Ontario, Canada

Yangzi Jiang, Northwestern University, Evanston, IL, United States, yangzi.jiang@kellogg.northwestern.edu, Jan A. Van Mieghem

There are 72 MRI hospitals from Ontario Canada connected under the Local Health Integration Networks that aim to serve 90% of their patients within their target wait time. Our dataset covering the last 5 years, however, shows that the actual number is only 40% meaning that over 60% of the patients experience waits in excess of their target. We show that smart routing of patients to farther, yet nearby lower utilized hospitals can increase the service level to 75% without adding capacity. Our analysis uses a geographical resource sharing queuing model that trades off increased driving distance with waiting time reduction to determine the effect of resource sharing under high server utilization.

3 - The Impact of Waiting Location on Customer Satisfaction: An Empirical Analysis of Preoperative Patient Flow

Dawson Kaaua, University of Pennsylvania, Philadelphia, PA, 19104, United States, kaaua@wharton.upenn.edu, Christian Terwiesch, Santiago Gallino

We study patients in an ambulatory endoscopy center who wait in reception then pre-op before receiving a procedure. We find evidence that (i) patients experience steeper declines in satisfaction in response to wait times in pre-op versus reception, (ii) patients may track first-in-first-out queue discipline in transparent areas of the queue despite the fact that patients do not observe the physician assignment of others waiting, and (iii) patients may be aware of the degree to which their wait concludes before or after a scheduled appointment time. We support and inform our observational findings with three experiments.

4 - Speed-quality Tradeoffs in Home Health: The Effects of Visit Length on Hospital Readmission

Hummy Song, The Wharton School, Philadelphia, PA, 19104, United States, hummy@wharton.upenn.edu, Elena Andreyeva, Guy David

This study uses a novel dataset from a home health agency to examine the presence of a speed-quality tradeoff in the context of home health care delivery. Specifically, we use an instrumental variable approach to quantify the effects of the length of a post-acute home health visit on the likelihood of readmission to the hospital. We find that longer than average home health visits are associated with a significant reduction in the likelihood of hospital readmission.

■ SC70

S- Jefferson A

IT-enabled Business Innovation

Sponsored: EBusiness

Sponsored Session

Chair: Yi-Jen (Ian) Ho, Pennsylvania State University, University Park, PA, 16802, United States

1 - Can Own-account Software Bring Performance to a Firm?

Jin Sik Kim, University of California, Irvine, Irvine, CA, 92602, United States, j.s.kim@uci.edu, Vijay C. Gurbaxani, Hwan Heo

As the data usage and software to process the data have become new resources to compete in daily transactions for all business, we hypothesize that it is own-account software creating unique value for a firm. As more software is acquired via the cloud as a service, software can be considered as a commodity rather than resources that underlie competitive advantage because of the RBV 4 conditions. However, we conclude that own-account software may bring the performance a firm by answering these questions: does the own-account software (AI) outperform in demand estimation than (1) human and (2) Cloud-based AI S/W? And, (3) does the own account AI give economic benefits for a firm by estimating demand better?

2 - Mobile App Adoption and Portfolio Diversification Evidence from a Quasi-natural Experiment in China

Che-Wei Liu, Indiana University, Bloomington, IN, 47405, United States, cwliu@iu.edu, Sunil Mithas, Po-An Hsieh, Yang Pan

Despite the economic importance and significance, few studies have examined the effects of mobile app use on individual investors' financial decisions. We leverage a quasi-natural field experiment with a difference-in-difference specification, and our results suggest that mobile app use by individual investors leads to an increase of 4.7% in portfolio diversification and an increase in the number of stocks. We also show that mobile app adoption leads to a decrease of portfolio volatility because of the increase of portfolio diversification. We conduct a variety of robustness tests to assess the stability of our findings and discuss implications for research, and practice.

3 - Estimating the Economic Impact of `humanizing' Customer Service Chatbots

Scott Schanke, University of Minnesota, Minneapolis, MN, 55401, United States, schan067@umn.edu, Gordon Burtch, Gautam Ray

We consider the economic impacts of `humanizing' autonomous customer service agents (chatbots) and do so via a field experiment. We automate a clothing buy-back process, where individuals engage with a chatbot to sell their used clothing. We estimate the impact on transaction conversion and price sensitivity by exposing consumers to exogenous variation of (1) price offers, (2) levels of chatbot anthropomorphism. We show that while introducing either a small or large degree of anthropomorphism increases conversion rates, introducing only moderate anthropomorphism is counterproductive. We also show that a large degree of anthropomorphism causally increases consumers' price sensitivity.

4 - The Impact of Emotion on Social Media Content Consumption: Evidence from Video Analysis on Live Streaming Platforms

Keran Zhao, University of Illinois at Chicago, Chicago, IL, United States, kzhao23@uic.edu, Yuheng Hu, Yingda Lu

As an emerging social media service, live streaming has been widely adopted by advertisers and companies as a powerful market tool. In this study, we examine how streamers' emotional expression influence the audience's engagement. To answer this question, we utilize the deep-learning methods to acquire both the emotional expression and audience attention from streaming video and chatting script. Our analysis yields that there is a positive relationship between emotion fluctuation and audience engagement. Our results provide actionable suggestions and shed light on understanding the live interaction on the live streaming platforms.

5 - The Price of Price on Online Advertising: Evidence From Randomized Field Experiments

Yi-Jen (Ian) Ho, The Pennsylvania State University, Smeal College of Business, University Park, PA, 16802, United States, ian.ho@psu.edu, Nitish Jain, Suresh Muthulingam

Consumers access the incomplete information of products while shopping online. The asymmetric product information results in uncertainty. We consider uncertainty driven by price and product valuation. Specifically, we examine the effect of price revelation on consumer choice and how the effect is moderated by search cost and product popularity. We conduct randomized field experiments on Facebook to qualify the causalities. The results show that the impacts of price revelation vary. While showing price deters the click-through rate, the consumers who click on the are more engaged. Mobile users prefer having price information, and popular products suffer from price revelation.

■ SC71

S- Jefferson B

Software for Network Analytics

Sponsored: Telecommunications and Network Analytics

Sponsored Session

Chair: Matthew Galati, SAS Institute, Inc., Glen Mills, PA, 19342, United States

1 - Pattern Matching for Graph Queries in Sas® Viya® 3.4

Matthew Galati, SAS Institute, Inc., 1164 Avonlea Circle, Glen Mills, PA, 19342, United States, matthew.galati@sas.com

SAS® Visual Data Mining and Machine Learning 8.4 in SAS® Viya® 3.4 includes the new patternMatch action, which you can use to execute graph queries that search for copies of a query graph within a larger graph, with the option of respecting node or link attributes (or both). This presentation also provides computational comparisons to both iGraph and Neo4j. Example applications include social network search and value-added tax fraud.

2 - Detecting Aberrant Linking Behavior in Directed Networks

Mark Velednitsky, University of California-Berkeley, Berkeley, CA, United States, marvel@berkeley.edu, Dorit Simona Hochbaum, Quico Spaen

Agents with aberrant behavior are common in today's networks: fake profiles, websites, news spread misinformation. The distinguishing behavior of networks with aberrant agents is that normal agents rarely link to aberrant ones. Based on this, we propose a directed Markov Random Field formulation for detecting aberrant agents. The formulation is solved optimally and efficiently. To assess our method, we develop a new variant of "modularity." In an empirical experiment, we compare to PageRank, TrustRank, and AntiTrustRank. We demonstrate that our method outperforms other detection algorithms.

3 - A Nonnegative Matrix Factorization Approach to Track Communities in Temporal Networks Using Node Features

Renny J. Márquez, PhD student, Universidad de Chile, Santiago, Chile, marquezrennyj@ug.uchile.cl, Richard Weber, André C.L.F. de Carvalho

Community detection is primarily based on the adjacency matrix of a network. Adding node attributes to the identification of groups can improve the detection of communities. This improvement can further increase when working with temporal networks. Besides, soft overlapping assignment of nodes to communities can be a good alternative to deal with uncertainty in data. In this context, we propose a community detection algorithm for finding soft overlapping groups in temporal networks with node attributes. Our approach is based on a non-negative matrix factorization generative model. Preliminary results on toy and artificial networks have been very promising

■ SC72

S- Columbia

Diversity/PSOR/MIF: Diversity, Equity and Inclusion in OR/MS/Analytics: Innovations in Research and Practice

Sponsored: Diversity, Equity, and Inclusion

Sponsored Session

Chair: Michael P Johnson, University of Massachusetts-Boston, Boston, MA, 02125-3393, United States

1 - A Research Agenda for Diversity, Equity and Inclusion in the Decision Sciences

Michael P. Johnson, PhD, University of Massachusetts-Boston, Department of Public Policy & Public Affairs, Boston, MA, 02125-3393, United States, michael.johnson@umb.edu

Scholarly research on diversity, equity and inclusion (DEI) in the decision sciences is largely concentrated in areas of management and organization design. However, DEI is relevant to other domains of inquiry, and can be understood in terms other than economic efficiency and organization effectiveness. I discuss what a research agenda in decision sciences would look like if DEI, and a focus on social costs and benefits and social justice were central to this work. Examples to be discussed include: the new economy, climate resilience and disaster response, and human services.

2 - Locating Cannabis Establishments in Areas of Disparate Impact

Jeffrey Moyer, MS, University of Massachusetts-Boston, Boston, MA, 02125-3393, United States, Jeffrey.Moyer001@umb.edu

How can a public agency aiming to correct previous criminal justice disparities and drive social equity pick the most eligible geographic areas for consideration? This paper will use cannabis establishment siting as an example of how to develop and conceptualize a diversity, equity, and inclusion agenda within the field of operations research by formulating measures of equity and fairness that reflect experiences of underserved, underrepresented or marginalized population and embrace multi- and trans-disciplinary alternative approaches.

3 - Migrant Inclusion in Development Management: A Social Network Analysis

Christopher C. Graham, MS, University of Massachusetts-Boston, Boston, MA, 02124, United States, chriscordellgraham@gmail.com

This study uses social network analysis (SNA) to conduct a meso-level investigation of migrant-driven development social systems. The SNA applies degree and eigenvector centrality measures to assess the inclusiveness of migrant organizations in collaborative networks within those social systems. Findings indicate that while migrant organizations are involved in development management, they are underrepresented or absent in highly-collaborative resource exchange networks. These findings offer new perspectives on how development policy-makers evaluate and understand migrant inclusion.

■ SC73

S- Boren

Risk Management for Performance-driven Energy Systems

Sponsored: Finance

Sponsored Session

Chair: Kory W. Hedman, PhD, Advanced Research Projects Agency-Energy US Department of Energy, Washington, DC, United States

1 - Performance of Energy Systems

Agostino Capponi, Columbia University, New York, NY, United States, ac3827@columbia.edu

We discuss robustness and resiliency of network architectures in a systemic context, with an emphasis on energy risk. We consider a network model, consisting of (1) a network interaction matrix capturing the pattern and extent of interaction between the generators of the energy network, (2) a demand and supply function, and (3) a network interaction function used by each generator in the network to compute its state based on the states of the others.

We introduce the metric of matrix majorization to quantify concentration of the network interaction matrix. We study how the interplay of demand-supply imbalance, and concentration of the network interaction matrix affect failures of generators.

2 - Renewable Energy Sources and the Risks they Pose: A Financial Industry Perspective

Ronnie Sircar, Princeton University, Princeton, NJ, United States, Rene Carmona

We present a parallel between the modeling challenges faced by the financial industry when attempting to estimate and predict the costs associated with defaults on debts, and the risks and costs faced by grid operators dealing with uncertain sources of energy. Next, we review some of the risk measures and credit products used by the financial industry to mitigate these risks, and we speculate on how these concepts could be leveraged in the context of the search for safe and reliable energy delivery.

3 - Enabling On-site Solar Transactions Through Novel Insurance Products

Jeffrey McAulay, Energetic Insurance, Boston, MA, United States

Solar Photovoltaics are one of the fastest growing sources of new electricity generation in the US. However, several risks still limit faster growth and adoption. While utility-scale and residential markets show strong growth, the commercial sector in particular has been largely flat. Here we review several known risks and highlight how insurance approaches can enable scale. Examples risks include electricity generation, off-taker credit, utility tariff rates and tax equity recapture. When paired with storage, high density solar deployment can be deployed in targeted areas to enable electric grid resiliency and defer infrastructure investment.

4 - Using Stochastic Models for Day-ahead Electricity Markets

John Birge, University of Chicago, Chicago, IL, United States, john.birge@chicagobooth.edu

Models for forward electricity markets that match deterministic bids and offers have an inherent inability to match both prices and quantities. This results in inefficiencies due to the lack of credible commitment. This talk will discuss this phenomenon in general and potential market remedies to improve efficiency.

■ SC74

S- Capitol Hill

Best Practices in Teaching OR/MS

Sponsored: Junior Faculty JFIG

Sponsored Session

Chair: Canan Gunes Corlu, Boston University, Boston, MA, 02215, United States

Co-Chair: Gokce Palak, Shenandoah University, Winchester, VA, 22601, United States

1 - Best Practices in Teaching OR/MS

Canan Gunes Corlu, Boston University, Boston, MA, 02215, United States, canan@bu.edu

Panelists from both business and engineering schools will share their experiences teaching OR/MS undergrduate and graduate courses both in face-to-face and online formats.

- Prakash Mirchandani, University of Pittsburgh, Katz Graduate School of Business, Pittsburgh, PA, 15260, United States
- Esra Buyuktahtakin Toy, Associate Professor, New Jersey Institute of Technology, Newark, NJ, United States, esratoy@njit.edu
- John Maleyeff, Boston University, Boston, MA, United States, maleyeff@bu.edu
- James J. Cochran, University of Alabama, Culverhouse College of Commerce & Bus Admin, Tuscaloosa, AL, 35487-0226, United States
- Dessislava Pachamanova, Professor, Babson College, Wellesley, MA, 02457, United States, dpachamanova@babson.edu

■ SC77

S- Fremont

Joint Session PMS/ED: Transforming a Project Management Course

Emerging Topic: Project Management & Scheduling

Emerging Topic Session

Chair: Theodore D. Klastorin, University of Washington, ISOM Department, Seattle, WA, 98195-3226, United States

1 - Teaching Agile versus Waterfall in Project Management Courses

Theodore D. Klastorin, University of Washington, ISOM Department, Seattle, WA, 98195-3226, United States

Agile Project Management is widely discussed and implemented but poorly understood. In this talk, we compare Agile to Waterfall and discuss how these two methodologies relate to various classes of risk (e.g., requirements risk versus schedule risk). In addition, we will define important open questions that must be considered by Agile users.

2 - A Case Based Project Planning/Risk Lesson

Gary Mitchell, University of Portland, Portland, OR, 97203-5798, United States

Most complex projects are characterized by a great deal of uncertainty and risk. Project managers must identify tasks, develop estimates, and determine schedules and costs under these conditions of uncertainty. Effectively teaching students about identifying and planning projects under risk requires establishing a theoretical foundation, providing practical tools they can understand and apply, and a practical application with which they can gain experience. In this talk, we present a case-based term project that has proven to be an effective method for teaching project managers planning under risk.

3 - Teaching Critical Chain Project Management: A Review of the Decade's Developments

William P. Millhiser, Baruch College City University of NY, New York, NY, 10010, United States

Critical Chain Project Management (CCPM) has been popular among practitioners and business schools but a subject of disagreement among scholars. We will review subsequent developments in CCPM practice and pedagogy, new teaching games, and share evidence of CCPM's transformation in teaching important PM thinking skills despite industry's wholesale movement toward agile methods in the modern digital economy.

4 - Teaching Forward-Looking Earned Value Analysis (EVA)

Jim Salmon, Boeing Company, Seattle, WA, United States

Traditional Earned Value Analysis (EVA) reporting methods emphasize the sanctity of the initial plan and comparisons of recent progress to it. Given EVA's prevalence in many types of projects, especially among those beholden to government contracting rules or oversight from external project customers, it behooves project managers to both understand and incorporate simple visualization tools and cues that compel re-articulation of plans based on possible future outcomes on an ongoing basis.

■ SC78

S- Greenwood

Network Research in Innovation and Knowledge Management

Sponsored: New Product Development

Sponsored Session

Chair: Hyunwoo Park, Ohio State University, Columbus, OH, 43210, United States

1 - An Economic Model of Knowledge Outsourcing

Jaeseok Lee, The University of Auckland Business School, Auckland, 0620, New Zealand, Cheryl Gaimon, Karthik Ramachandran

We introduce a game-theoretic model of knowledge outsourcing. We study how the interaction between a knowledge buyer and supplier is affected by two distinctive aspects of knowledge outsourcing: absorptive capacity and the ability to leverage prior knowledge. We also investigate how uncertainty and information asymmetry influence the equilibrium outcomes.

2 - The Impact of Service Failure of Competitors on Innovation

Seongkyoon Jeong, PhD Student, Arizona State University, 451B, Department of Supply Chain Management, Business Administration, Tempe, AZ, 85281, United States, sjeong19@asu.edu, Adegoke Oke

Firms can not only learn from service failure of rivals but also capture new customer base resulting from the service failure. Using the data of online game services, we investigate how firms gain value from service failure of competitors through innovation and the role that supply chain plays in this process. Using 65 major service failure and update data of 435 online game services hosted between 2014 and 2017, this study finds that competitor's service failure shortens the duration of major service updates and that the publisher-developer tie strength has an inverted U-shape relationship with the responsiveness of major service updates to the competitor's service failure.

3 - Technological Innovation Spillover in Supply Networks

Hyunwoo Park, Ohio State University, Columbus, OH, 43210, United States, park.2706@osu.edu, Waleed A. Muhanna

In this work, we study how innovation outcomes propagate in supply networks. We examine whether suppliers' innovation is substitute or complement to the innovation portfolio of the buyer. Thus, our empirical analysis include the effect of supplier innovation on buyer's supplier portfolio and own innovation activities. We also consider spillover through indirect relationships in supply networks.

4 - Incentive Metrics in the Presence of Project Performance and Task Interdependence Uncertainties

Antoine Feylessoufi, University of Cambridge, Cambridge, United Kingdom, af545@jbs.cam.ac.uk

We analyse how team and individual incentives affect an organization's propensity to adopt a risky strategic project. We recognize that these projects are mostly carried out by a cross-functional team of specialists whose tasks are interdependent and uncertain, and the degree to which their tasks interact is also uncertain. In particular, we show that the project performance uncertainty and the uncertainty around the interdependence of the tasks can impact the incentive metrics in opposite ways.

■ SC79

S- Issaquah A

Market Design for a Low-Carbon Electricity Grid

Emerging Topic: Sustainable Growth

Emerging Topic Session

Chair: Jacob Mays, Northwestern University, Evanston, IL, 60208, United States

Co-Chair: Brent Eldridge, Johns Hopkins University, Baltimore, MD, 21201, United States

1 - Long-term Equilibrium in Low-carbon Electricity Markets

Audun Botterud, Massachusetts Institute of Technology, Cambridge, MA, 02140, United States, audunb@mit.edu, Magnus Korpås

We formulate generation capacity portfolio planning in the power grid as a least-cost optimization problem and derive analytic expressions for the cost recovery conditions for dispatchable generation, variable renewable energy (VRE), and energy storage. Using a simple load duration representation of electricity demand, we illustrate how the long-term market equilibrium changes for different VRE penetration levels. We also illustrate how long-term contracts for VRE typically do not account for the resulting balancing needs in the system. We propose alternative mechanisms that align better with short-term system needs and long-term equilibrium conditions.

2 - Do Electricity Market Price Formation Efforts Still Matter in a High Renewable World?

Robin Broder Hytowitz, Electric Power Research Institute, Palo Alto, CA, 94062, United States, Erik Ela

With more zero marginal cost resources coming online, there are questions as to the value of alternative pricing mechanisms in electricity markets. This presentation will discuss market designs behind US ISO and RTO efforts dealing with price formation. We will explore the relevance of these efforts in light of higher penetration renewable energy and ongoing market changes.

3 - Implications of Indivisibilities on Pricing with Constrained Delivery

Alberto J. Lamadrid, Lehigh University, Bethlehem, PA, United States, ajl259@cornell.edu

We study a market with non-convexities for goods delivered over a network subject to congestion. Our model is inspired on an electricity market with non-convexities associated with commitment costs and convex quadratic generation costs, from the viewpoint of a market-maker that determines market clearing prices for participants.

4 - A Learning Algorithm to Estimate Inefficiencies in Electricity Markets

Brent Eldridge, Johns Hopkins University, Baltimore, MD, United States, breldridge@gmail.com, Richard O'Neill

Independent System Operators (ISOs) are largely effective at coordinating wholesale electricity markets. In such markets, the ISO determines prices and quantities based on the solution of a Unit Commitment (UC) problem. However, the UC problem is non-convex, e.g., due to lumpy start-up costs or on/off commitment decisions, so prices cannot generally support the optimal schedule. Various pricing methodologies have been proposed, but there is no accepted consensus of what constitutes an optimal pricing policy. This presentation applies agent-based modeling (ABM) to model how various pricing methodologies may affect generator offer curves and consequently the affect on market efficiency.

■ SC80

S- Issaquah B

Driving Innovation in Different Industries

Sponsored: Technology, Innovation Management & Entrepreneurship

Sponsored Session

Chair: Jochen Schlapp, Frankfurt School of Finance & Management gGmbH, Frankfurt am Main, 60322, Germany

1 - Operations in Space: Exploring a New Industry

Joel Wooten, University of South Carolina, Columbia, SC, United States, Christopher S. Tang

Private, commercial spaceflight is changing the course of space exploration. This new space market presents different challenges, and as a result, our paper analyzes the opportunities for novel contributions from the operations management community.

2 - Sourcing Innovation: The Role of Internal Suppliers in Procurement Contests

Zhi Chen, INSEAD, 1 Ayer Rajah Ave, Singapore, 138676, Singapore, zhi.chen@insead.edu, Jurgen Mihm, Jochen Schlapp

One of the central questions in the strategic procurement of innovative goods is whether a buyer should own a stake in a critical supplier or not. In this study, we analyze when a buyer should source from external suppliers exclusively and when it should (partially) own one of the suppliers.

3 - Sparking Manufacturing Innovation: How Temporary Interplant Assignments Affect Employee Idea Values

Fabian J. Sting, University of Cologne, Albertus-Magnus-Platz, c/o WiSo-Sekretariat Universitaetsstrasse 91, Cologne, 50923, Germany, sting@wiso.uni-koeln.de, Philipp Benjamin Cornelius, Bilal Gokpinar

We study how interplant assignments - short-term, temporary employee moves between factories - influence employee-driven manufacturing innovation. Using unique idea-level data from a large European car parts manufacturer, we show that interplant assignments are a significant driver of employee idea values by fostering the short-term transfer of production knowledge as well as long-term employee learning. We also find that both knowledge transfer and employee learning are facilitated by assignments to plants that are functionally similar (i.e., plants that have similar products and processes).

4 - A Simple Economic Analysis of Contest Platforms

Sanjiv Erat, University of California-San Diego, Rady School of Management, Otterson Hall, La Jolla, CA, United States

Firms, such as Innocentive and Topcoder, offer platforms that enable crowdsourcing of innovations and of technical solutions from large communities of potential solvers. The current talk shall develop a simple economic model of contest platforms that clarifies how the challenges of conducting a contest on a platform is distinct from the case of "monopolist" contests (analyzed in all of past literature). Insights and contingent recommendations are derived that explain when and which type of platforms offer firms a better value and why.

5 - Product Selling Versus Pay-per-use Service: A Strategic Analysis of Competing Business Models

Stylianos Kavadias, Margaret Thatcher Professor of Innovation & Growth, University of Cambridge, Judge Business School, Trumpington Street, Cambrige, CB2 1AG, United Kingdom, s.kavadias@jbs.cam.ac.uk, Konstantinos Ladas, Christoph H. Loch

We present a model that explains why "pay-per-use" (PPU) business models may have become profitable alternatives to traditional selling business models across a wide range of goods in a competitive setting. Our model features goods of any production cost, used by consumers who vary in their usage. We find that PPU models are more profitable than selling models, as long as their logistics costs are not too high, a requirement more easily fulfilled as new technologies reduce logistics costs. These results hold across a wide variety of settings. If the service providers vary their service level they further increase their advantage because they lure away even the high usage consumers.

■ SC81

S- Kirkland

Forestry III: Wildfire Management

Sponsored: Energy, Natural Res & the Environment/Forestry

Sponsored Session

Chair: David L Martell, University of Toronto, Toronto, ON, M5S 3B3, Canada

1 - Data Driven Metrics for Resource Scarcity Within the Wildland Fire Response System

Erin Belval, Research Scientist, Colorado State University, Fort Collins, CO, United States, Dave Calkin, Crystal Stonesifer

Quantitative measures of resource scarcity are crucial for making decisions across a range of spatial and temporal scales within the wildfire response system in the United States. From national preseason decisions to real-time incident level decisions, accurate measures of resource scarcity may affect a variety of resource allocation decisions. Despite the potential utility of resource scarcity metrics, the question of how to define resource scarcity can be difficult to answer. Using a variety of available resource use data we define scarcity measures for national resources at multiple spatial and temporal levels and discuss their relevance to ongoing management challenges.

2 - Contingency Fireline Selection in Large Fire Suppression

Yu Wei, Colorado State University, Department of FRWS, Forestry 102, Fort Collins, CO, 80523, United States, yu.wei@colostate.edu, Matthew Thompson, Erin Belval, Benjamin Gannon, Dave Calkin

Large fire management decisions often need to be made with uncertainties. One of the major uncertainties is due to potential fireline breaching. Key primary firelines may need to be backed up by contingency lines to lower the risk of line breaching. Building contingency lines is costly, but may create necessary redundancies in the large fire suppression system. A MILP model is used to explore where contingent firelines should be built to improve the expected system performance during large fire suppression.

3 - Predictive Analytics and Machine Learning in Wildfire Management

Matthew Thompson, U.S. Forest Service, Fort Collins, CO, United States, Christopher O'Connor, Dennis Hallema, Yu Wei

Inspired by Dave Martell, this presentation will outline an integrated analytics management framework in the context of fire suppression operations. We will introduce a descriptive fire line effectiveness framework, and describe its role in serving as a connective thread for predictive and prescriptive analytics. Emphasis will be placed on predictive models built with machine learning algorithms, and we will share real-world examples of their use for planning and decision support. Lastly we will outline research directions for machine learning, including aiming to build predictive models of suppression operations like fire line construction, aerial drops, and resource use dynamics.

4 - A Daily Airtanker Deployment Decision Support System

David L. Martell, University of Toronto, Faculty of Forestry, 33 Willcocks Street, Toronto, ON, M5S 3B3, Canada, david.martell@utoronto.ca

Each day forest fire managers must decide where to deploy their airtankers and their alert status throughout the day to minimize their response time to new initial attack fires. The airtanker system can be viewed as a complex spatial queueing system with fires as customers, airtankers as servers, fire arrival rates that vary over time, uncertainty concerning the number of airtankers required to serve each customer and service times that depend on waiting time. We describe a hybrid decision support system comprised of a simple deterministic location model that is coupled with a simulation model that can be used to help evaluate daily airtanker deployment strategies.

■ SC82

S- Leschi

Capacity Expansion of Energy Systems under Uncertainty

Sponsored: Energy, Natural Res & the Environment/Electricity

Sponsored Session

Chair: Liang Xu, University of Pittsburgh, Pittsburgh, PA, 15261, United States

1 - A Nonconvex Regularization Scheme for the Stochastic Dual Dynamic Programming Algorithm

Arnab Bhattacharya, Staff Research Scientist, Pacific Northwest National Laboratory, Richland, WA, 99354, United States

A novel nonconvex regularization scheme is proposed to improve the performance of the stochastic dual dynamic programming (SDDP) algorithm for solving multistage stochastic linear programs. Specifically, a class of nonconvex functions, called folded-concave penalty, is used to improve both solution quality and convergence rate of SDDP. Equivalent mixed-integer programming formulations are derived, and global optimality and convergence guarantees of the procedure are established. The potential benefits of the regularization scheme are demonstrated for two large-scale multistage problems in energy and finance.

2 - Multiple N-1-1 Contingency-Constrained Two-Stage Stochastic Expansion Planning with Corrective Actions

Daniel A. Zuniga Vazquez, University of Arizona, Tucson, AZ, United States, danielzunigav@email.arizona.edu, Neng Fan

Shortages of critical loads may be generated due to unexpected outages caused by extreme weather conditions, among other factors. Therefore, to achieve a reliable transmission and generation expansion planning security criterions must be ensured. A two-stage stochastic optimization model is presented for minimizing the expansion planning cost considering DC optimal power flow, and contingency-constrained DC optimal power flow, such that it satisfies multiple N-1-1 survivability criteria with corrective actions. For an efficient solution, a decomposition algorithm is adapted, and the model is assessed using modified versions of IEEE test cases.

3 - Capacity Expansion of Wind Farm in a Market Environment under Uncertainty

Liang Xu, University of Pittsburgh, Pittsburgh, PA, 15261, United States, lix21@pitt.edu, Bo Zeng

Uncertainty and instability are widely existing in wind power generation. To have reliable investment decisions, we introduce a bilevel model considering uncertainty. The upper level aims to maximize wind power profit subject to investment budget constraints while the lower level is to minimize the overall cost through a market clearing problem. By computing instances from typical test beds, we note that our proposed model and solution methods demonstrate significant advantages in practice.

4 - Enabling Smart Ports Through the Integration of Microgrids

Anahita Molavi, University of Houston, Houston, TX, United States, amolavi@uh.edu, Jian Shi, Gino J. Lim

This paper presents a systematic framework for port microgrid planning as well as evaluating the influence of microgrids adoption on an industrial port's performance. A set of modified Smart Port Index (SPI) metrics are incorporated in the proposed framework to demonstrate how the microgrid integration can holistically improve the smartness of the port. A two-stage stochastic mixed-integer model was developed to evaluate the effectiveness of the proposed approach under uncertainties. Numerical results indicate that compared with the minimum cost planning approach, the proposed framework is capable of improving the productivity, sustainability, and reliability of the port operations.

■ SC83

S- Medina

Energy pricing for Demand Response

Sponsored: Energy, Natural Res & the Environment/Electricity

Sponsored Session

Chair: Juan Gomez Herrera

1 - Optimal Time-and-level-of-use Price Setting for an Energy Retailer

Juan Alejandro Gomez-Herrera, Polytechnique Montreal, 1350 Palerme 111, Montreal, QC, J4W 0A1, Canada, Miguel F. Anjos, Luce Brotcorne

We present a novel pricing optimization problem for an energy retailer in a smart grid. In this framework the retailer buys energy from multiple generators via bilateral contracts and sells it to a population of smart homes using Time-and-Level-of-Use tariffs (TLOU). TLOU is an energy price structure recently introduced in the literature, where the prices vary depending on the time and the level of consumption. This problem is formulated as a bilevel optimization problem, in which the energy retailer wants to set the prices that maximize the profit, anticipating the reaction of a population that wants to minimize the cost by shifting load.

2 - Sustainable Management of Data Centers with Onsite Renewables Considering Reduction of Greenhouse Gases Emissions

Jose Luis Ruiz Duarte, University of Arizona, Tucson, AZ, 85721, United States, jlruizduarte@email.arizona.edu, Neng Fan

The processing of large amounts of data is an essential task addressed by data centers, which account for an important portion of the power consumed by information technologies. There is a necessity to improve the data centers' energy efficiency. In this presentation, the development of a two-stage robust optimization model for job migration and assignment of a network of interconnected data centers, each of them equipped with energy storage systems and renewable energy sources with uncertain power output and operating under demand-side management policies, is shown. A sensitivity analysis is performed under scenarios of connectivity and availability of technologies used on each center.

3 - Time of Use Pricing for Demand Response

Luce Brotcorne, INRIA, 40 Avenue Halley - Bat A, Parc Scientifique de la Haute Borne, Lille, 59650, France, luce.brotcorne@inria.fr

We present an optimal pricing approach for an energy retailer in a context of smart grid and demand response. The retailer buys energy on the energy market and sells it to a smart grid aggregator whose goal is to schedule consumers' household appliances at the lowest cost with regard to electricity prices and delays. The smart grid operator has a renewable energy source and a battery. A multi-period stochastic bilevel model is defined. Numerical results are commented on.

4 - A Hybrid Genetic Algorithm - MILP Solver Bilevel Approach to Optimize Electricity Dynamic Time-of-use Pricing

Carlos Henggeler Antunes, University of Coimbra, INESCC, Dept Electrical and Computer Engineer, University of Coimbra, Polo 2, Coimbra, 3030-290, Portugal, ch@deec.uc.pt

In smart grids, dynamic tariffs are expected to become commercial offers by retailers to encourage the adoption of different consumption patterns using the flexibility in the operation of end-use loads. Bilevel optimization is adequate to model the interaction between the retailer and consumers. The retailer aims to set prices to maximize profits and the consumer responds by selecting, under that price setting, a load scheduling decision to trade-off cost vs. comfort. A hybrid genetic algorithm - MILP solver approach is proposed to deal with this problem.

■ SC84

S- Ravenna A

Performance Based Energy Resource Feedback, Optimization, and Risk Management (PERFORM)

Sponsored: Energy, Natural Res & the Environment/Energy

Sponsored Session

Chair: Kory Hedman, ARPA-E, US DOE, DC, United States

1 - Demand Side Risk Management for Electricity Supply

Shmuel S. Oren, University of California-Berkeley, Berkeley, CA, United States, shmuel@berkeley.edu

The emerging penetration of distributed resources and renewable resources into the electricity supply mix and increased demand side participation in the management of the electric power system requires new business models for electric utilities and innovative approaches for risk management along the electricity supply chain. The economic gains from a transactive energy paradigm that envisions the proliferation of energy balancing through increased self supply and peer to peer transactions at the distribution level can only be realized by mitigating part of the supply risk through demand side mechanisms and edge technologies. This talk will discuss such mechanisms and service contracts.

2 - The Four Classes of Policies for Stochastic Optimization in Energy Systems

Warren Powell, Professor, Princeton University, Princeton, NJ, United States, wbpowell328@gmail.com

Energy systems, especially with the growth of renewables, represents a rich class of sequential decision problems under uncertainty. I will review the four classes of policies that are the foundation for any sequential decision problem, and illustrate this using a simple energy storage system. I will highlight a powerful strategy, the parametric cost function approximation, that formalizes a practice widely used in industry for problems such as unit commitment, and I will demonstrate that this approach will outperform the scenario-tree approach to stochastic unit commitment.

3 - Dealing with Risk and Uncertainty in the Electric Sector: Lessons from the Financial Sector

Richard D. Tabors, Tabors Caramanis Rudkevich, Boston, MA, United States, rtabors@tcr-us.com, Michael Caramanis, Panagiotis Andrianesis, Alexandr Rudkevich, Pablo Ruiz

The objective of this paper is to work from the realities of the electric power system of today and look to alternate paradigms that can provide both insights and mathematical approaches to address the increases in risk and uncertainty brought about by renewable technologies and distributed energy resources. The development of the Black-Scholes and binomial models in option theory are but two examples of ways in which uncertain futures have been quantified in the financial sector. How can these be used to address the critical operational and planning variables of space and time in the electric sector.

4 - Fuel Neutrality in Capacity Markets

David Morton, Northwestern University, Evanston, IL, United States, david.morton@northwestern.edu

We investigate the fuel neutrality of capacity mechanisms implemented in liberalized electricity markets. We consider a stochastic equilibrium model for a competitive, but incomplete, market with risk trading. Our results suggest that introduction of a capacity mechanism can have asymmetric effect on the risk profile of different generation technologies. This is joint work with Jacob Mays and Richard O'Neill.

■ SC85

S- Ravenna B

Natural Gas Markets II

Contributed Session

Chair: Felipe A. Feijoo, Pontificia Universidad Católica de Valparaíso, Av. Brasil 2241, Office 6-8, Valparaíso, Chile

1 - Are We Facing a Globally Integrated Natural Gas Market? – A Spatial Equilibrium Approach

Ekaterina Dukhanina, MINES ParisTech, Paris, France

We applied a spatial equilibrium model, allowing estimation of unobservable part of transaction costs and arbitrage rent, to examine the degree of integration between natural gas markets in different regions (i.e., Europe, North America, and Asia). Based on the optimality conditions of a swing LNG producer's profit-maximization problem, the model estimates probabilities of observing spatial equilibrium between the markets using maximum likelihood method. The results show that it is too early to speak about a perfectly integrated global gas market, because the estimated probability of the markets to be in spatial equilibrium remains low and a spatially inefficient trade is detected by the model.

2 - A Multistage Stochastic Programming Approach for Preventive Maintenance Scheduling of Gencos with Natural Gas Contract

Zhouchun Huang, Nanjing University of Aeronautics and Astronautics, Nanjing, China, zhouchun.huang@knights.ucf.edu, Qipeng Phil Zheng

A preventive maintenance scheduling problem is presented for generation companies (GENCOs) with natural gas power plants, taking into account signed natural gas contracts and the opportunity of purchasing and selling natural gas in the spot market. This paper considers the uncertain prices of both natural gas and electricity in the spot market, and develop a multistage stochastic mixed integer programming model seeking the optimal operations regarding generation dispatch, maintenance outage plan and natural gas trading. A progressive hedging algorithm based on the scenario-based decomposition is developed and implemented with parallel computing for solving large-scale problems.

■ SC86

S- Ravenna C

Open-source Tools for Energy-Water-Land-Climate Assessment

Sponsored: Energy, Natural Res & the Environment/Energy

Sponsored Session

Chair: Daniel Huppmann, International Institute for Applied Systems Analysis (IIASA), Vienna, 1100, Australia

1 - Wind Power Versus PV: The Cost of Undisturbed Landscapes

Sebastian Wehrle, University of Natural Resources and Life Sciences, Vienna, Austria, Johannes Schmidt

In Austria, the system cost minimizing mix of renewable electricity generation technologies is dominated by wind power. However, land-use constraints may limit the deployment of additional wind turbines. Using the power system model MEDEA, we investigate the effects of substituting wind power with PV. Preliminary results suggest that a) a small deviation from the power system-wide least cost technology mix might be beneficial for Austria (but not for its neighbors) and b) strong substitution of wind power with PV increases system cost, emissions from power generation and producer surplus.

2 - An Open Platform or Optimizing Energy-water-land System Transformations Towards Sustainable Development

Adriano Vinca, International Institute for Applied Systems Analysis, Laxenburg, Austria, vinca@iiasa.ac.at
Adriano Vinca, University of Victoria, Victoria, BC, Canada, vinca@iiasa.ac.at, Simon Parkinson

The NExus Solutions Tool (NEST) is a new open modeling platform that integrates multi-scale water-energy-land (WEL) resource optimization with distributed hydrological modeling designed to aid decision-makers with complex planning regarding the integrated development of WEL resources in a river basin. NEST provides insights into the vulnerability of resources to future socioeconomic and climatic change and solutions to improve the resilience and sustainability of transformation pathways while avoiding counterproductive interactions among sectors. We apply NEST to the Indus River Basin, a region where long-term management of WEL systems is fundamental for the sustainable development.

3 - Reinforcement Learning Methods for Energy Market Auctions

Claude Kloeckl, University of Natural Resources and Life Sciences, Vienna, Austria, Johannes Schmidt, Christoph Graf

Auctions are essential in economics & the energy sector. Traditionally, auctions are treated by game theory, but analytical treatment is hard. Real-world game theoretic models (e.g.: the Italian energy market) introduce numerous binary constraints. This impairs their numeric solvability. An alternative may be reinforcement learning, that adapts an initially naive strategy towards an efficient strategy. It divides into q-learning & policy gradient methods. Both suffer from complementary drawbacks that hinder the analysis of auctions. Recently, deep q-learning gained attention by learning to play video games. It reconciles the disadvantages of prior methods and may help explain auctions.

4 - Hector - A Computationally-efficient, Open-source, Community-based Global and Regional Climate Emulator

Corinne Hartin, Joint Global Change Research Institute, Riverdale, MD, United States, Ben Bond-Lamberty, Pralit Patel, Robert Link, Abigail Snyder, Kalyn Dorheim

Recent developments to Hector, a reduced-form climate model and a series of open-source, computationally efficient, well documented tools allow a user to emulate global means from the CMIP5 archive (or any other climate model), sample parametric uncertainty space, and run large ensembles of regionally resolved temperature and precipitation based off on an arbitrary emission pathway. These capabilities open the door for significant research on human-earth system impacts within a fully coupled framework.

5 - The Potential for Re-powering Wind Turbines: Reducing Turbines, Increasing Output

Peter Regner, University of Natural Resources and Life Sciences, Vienna, Austria, Katharina Gruber, Johannes Schmidt, Claude Klöckl

Re-powering old wind turbines, i.e. replacing old ones by newer models, is a way of increasing energy output at productive locations, re-using existing infrastructure and reducing conflicts over land. We study the potential for re-powering wind turbines on the basis of a case study in the US. The increase of power output is estimated by simulating the output of an optimal deployment of new turbines using wind speed data. In addition, also other effects of re-powering, such as variability of output, size and distances between turbines, are assessed.

6 - Pyam: An Open-source Python Package for Integrated-assessment Analysis & Visualisation

Daniel Huppmann, International Institute for Applied Systems Analysis (IIASA), Vienna, 1100, Austria, huppmann@iiasa.ac.at, Matthew Gidden

We present the open-source `pyam` Python package for analysis, validation and visualisation of IAMC-style timeseries, including results from integrated assessment models of the energy system, sustainable development, and climate change mitigation. The talk showcases how `pyam` supported the assessment in the IPCC Special Report on Global Warming of 1.5°C, and steps to increase transparency and reproducibility of the IPCC analysis.

Sunday, 3:10PM - 4:00PM

■ Keynote

CC- Room 6C

Keynote: Analytics at the University of Cincinnati: A History of Innovation and Practical Impact (UPS George D. Smith Prize)

Emerging Topic: Keynote

1 - Analytics at the University of Cincinnati: A History of Innovation and Practical Impact

Michael Fry, University of Cincinnati, Carl H. Lindner College of Business, ncinnati, OH, 45221-0130, United States, Glenn Wegryn

The Operations, Business Analytics & Information Systems (OBAIS) Department in the Carl H. Lindner College of Business at the University of Cincinnati has a proud history of impact on the practice of analytics. For more than 50 years, the OBAIS Department has partnered with industry, produced thought-leading research, and influenced the teaching of analytics. In this presentation, we will provide an overview of the historical and current innovative activities undertaken by the OBAIS Department that culminated in its receiving the 2019 INFORMS UPS George D. Smith Prize.

■ Keynote

CC- Room 6B

Keynote: Data Science in Online Marketplaces: An OR Perspective

Emerging Topic: Keynote

1 - Data Science in Online Marketplaces: An OR Perspective Presenter

Bar Ifrach, Airbnb, San Francisco, CA, United States

Online marketplaces have seen immense growth in the past decade, opening the door to novel problems in prediction, control and optimization under the umbrella of Data Science. In this talk, we will focus our attention on pricing and matching problems in online marketplaces, drawing on examples at Uber Freight — an online marketplace for freight transportation. We will highlight the connection of these problems to operations research and economics.

■ Keynote

CC- Room 6A

Keynote: Structured Optimization for Dexterous Robots

Emerging Topic: Keynote

Emerging Topic Session

1 - Structured Optimization for Dexterous Robots

Russ Tedrake, Massachusetts Institute of Technology, Cambridge, MA, 02139, United States

Despite the incredible apparent success of robotics on youtube, robots are still surprisingly bad at some tasks that we expect them to do well — for example, robots are still relatively inept when it comes to manipulating objects with their hands. A major challenge in robotic manipulation is the diversity of the desired tasks: how do we rigorously formulate the problem of chopping vegetables, or putting away the dishes? Taking an optimization-based approach, then what is the cost function and what are the constraints? Can we even evaluate the performance of the system before we have developed a perception system that is capable of interpreting raw camera images to understand the number and location of various vegetables and/or plates in the scene?

In this talk, I'll describe our attempts to bring rigorous tools from optimization to bear on the problem of "open-world" robot manipulation. I will describe the non-smooth mechanics of making and breaking contact between the robot and the world, and how planning and control for non-smooth mechanics can be formulated using combinatorial+convex optimization like mixed-integer programming and/or semidefinite relaxations. I'll describe the deep learning approaches that we are using for perception and learning "intuitive physics". And I'll describe some of the challenges of verifying learning autonomous systems of this complexity, including calibrating the complex distributions (with categorical and continuous random variables) that we use to describe the distribution over environments.

Sunday, 4:30PM - 6:00PM

■ SD01

CC- Room 201

Data Analytics in Agriculture and Bioinformatics

Sponsored: Data Mining

Sponsored Session

Chair: Guipinh Hu

1 - Operations Research Methods for Enhancing Efficiency in Plant Breeding

Saba Moeinizade, Iowa State University, Ames, IA, 50014, United States, sabamz@iastate.edu, Guiping Hu, Lizhi Wang

Genomic selection (GS) is a technique that plant breeders use to select individuals to mate and produce new generations of species. To enhance the efficiency of breeding projects, we design an operations research framework to develop new GS algorithms. This framework has two main components: 1) Optimization and 2) Simulation. The first component is optimizing the selection, mating and allocation decisions that are critical in a breeding project and the second component is simulating the reproduction step to generate the next generation of individuals. We demonstrate the effectiveness of our algorithms using case studies with realistic datasets.

2 - A New Method for Plant Diseases Recognition with Small Dataset Based on Generative Adversarial Network

Guiping Hu, Iowa State University, 3014 Black Engineering, Ames, IA, 50011, United States, gphu@iastate.edu, Luning Bi

Convolutional neural network (CNN) is among the widely used methods for plant diseases classification with image data. However, training the model requires significant amount of labeled data. In most cases, the dataset used for training is often small due to significant data collection and annotation work. In this case, the CNN will have the overfitting problem. In this study, a Generative Adversarial Network (GAN) based method has been proposed to enlarge the dataset. Different from the ordinary GAN, our GAN is combined with a regularization kernel. Experiments show that adding the GAN-generated data effectively improves the recognition accuracy of plant diseases by 3%-5%.

3 - Designing Optimized Weighted Ensembles to Predict Corn Yield

Mohsen Shahhosseini, Iowa State University, Ames, IA, 50010, United States, mohsen@iastate.edu

Predicting corn yields for Iowa counties with the use of machine learning algorithms is the objective of this study. An optimization framework is designed that finds the optimal weights in creating ensembles from multiple individual learners with respect to tuned hyperparameters. The yields are derived from USDA-NASS. Besides, SSURGO database was used to obtain soil parameters, and weather information was retrieved from Daymet. The performance of designed framework is evaluated and compared with individual learners and unweighted average ensembles. Furthermore, data requirements for achieving acceptable prediction accuracy and ranking the importance of different inputs is discussed.

4 - Prediction of the Performance of Maize Hybrids via Machine Learning Methods Using Dna Markers and Seedling Transcriptome Profiles of Parents and Offspring

Fatemeh Amini, Iowa State University, Ames, IA, United States, famini@iastate.edu

Agronomic traits of maize hybrids with complex genetic architecture can be predicted by combining genomic data of both parents and offspring. As the dimension of variable (predictor) space increases, the model complexity increases with the reduction of information lost. To handle this challenge, a linear model is designed to predict the hybrids phenotypes using DNA and RNA sequence data from parents and offspring as its variable sets. Partial Least Squares (PLS) is used to predict gene expression patterns (RNA accumulation) of parents and offspring based on their DNA markers prior to predicting final traits. The proposed model was tested on 27 inbred parents and their offspring with ~6,600 genes.

5 - Deep Learning Based Models for Crop Yield Prediction

Saeed Khaki, Iowa State University, Ames, IA, 50010, United States, skhaki@iastate.edu

Crop yield is a highly complex trait determined by multiple factors such as genotype, environment, management practices, and their interactions. Deep learning models are powerful tools which can reveal the functional relationship between yield and these interactive factors. In this talk, we present how these models can be used to accurately predict crop yield across different environments.

■ SD02

CC- Room 202

Text Analytics in Data Science

Sponsored: Data Mining

Sponsored Session

Chair: Onur Seref

1 - Human Learning-guided Design of a Transfer-learning Framework for Text Analytics

Long Xia, Virginia Tech, Blacksburg, VA, 24061, United States, longxia1@vt.edu, Alan Gang Wang, Weiguo Fan

Transfer learning has been widely utilized in many real-world applications, including text analytics. However, there is limited research on how to project this human learning ability and use cognitive theory to guide machine learning design. In this study,we follow the design science paradigms to propose a research framework to integrate different transfer learning approaches. We evaluate our design artifact on a wide spectrum of text analytics tasks, and consistent improvements could be obtained by our proposed transfer learning framework. The detailed implementations and results, as well as theoretical and practical implications will be presented.

2 - A Simulation Based Framework to Study Opinion Dynamics in Social Networks

Derya Ipek Eroglu, Virginia Tech, Blacksburg, VA, 24061, United States, deryaipek@vt.edu, Onur Seref

Learning opinion shifts over a social network using agents has been a trending topic of interest. In this study, we introduce a framework that combines text analytics, simulation, and machine learning to analyze underlying patterns in opinion dynamics in social media. We study the effect of information generated by users or news websites and shared by the agents on a social network to develop an opinion model. Based on this opinion model, we build a network-based simulation model, whose input comes from textual Twitter data. The output of the simulation model is then fed to a machine learning model to study the underlying opinion dynamics.

3 - Context Maps: An Efficient, Flexible and Interpretable Framework for Visualizing Text

Onur Seref, Associate Professor, Virginia Tech, Pamplin Hall, Blacksburg, VA, 24061, United States, seref@vt.edu, Sukhwa Hong, Michelle M.H. Seref

We present a novel text analytics framework that combines conventional text mining methods, graph theory, distributed representations, and information theory to create efficient, flexible, and interpretable visualizations for textual data that we call context maps. We apply context maps to consumer reviews to identify regions of interest with respect to contrasts in review features. We use information-theoretic measures to compare different context maps, and track changes over time for a longitudinal analysis of time-stamped corpora.

4 - Exploring the Landscape of Consumer Review Helpfulness via Context Maps

Sukhwa Hong, Virginia Institue of Technology, Pamplin College of Business, 880 West Campus Drive, Blacksburg, VA, 24061, United States, sukhwa@vt.edu, Onur Seref, Michelle M.H. Seref

Understanding qualitative factors of online reviews that determine the consumer's perceived helpfulness is important for understanding the purchase process and consumers' decision making. We study the qualitative factors that determine the helpfulness of online product reviews using context maps. We provide a comparative study of other text visualization methods in the literature as a benchmark and highlight the capabilities of context maps against these methods.

■ SD03

CC- Room 203

Optimization Methods for Data Assimilation

Sponsored: Data Mining

Sponsored Session

Chair: Dimitri Papadimitriou

1 - Data-driven MIP-based Optimisation for Efficient Failure Detection in Large-Scale Systems

Tiejun Ma, University of Southampton, Southampton, United Kingdom, Btissam Er Rahmadi

We propose a new Mixed-Integer Programming (MIP)-based Failure Detector (FD), which consists on estimating optimal FD parameters that explore the optimal trade-off between FD's performance metrics, such as accuracy and speed. We model the system as a MIP optimization problem that aims at maximizing performance metrics while considering network conditions and resource constraints. Basically, this FD analyses then fits the behavior of messages delays and losses to include them in the FD decisions. We also propose a heuristic algorithm to address scalability challenge. Collected test results (Amazon EC2) show consistent improvement of overall failure detection quality and scalability.

2 - Second-Order Optimization Methods for Data Assimilation

Dimitri Papadimitriou, University of Antwerp, 24 rue du Charme, Brussels, 1190, Belgium, dimitri.papadimitriou@uantwerpen.be

The interplay between optimization and data science has mainly focused since so far on either algorithmic or statistical data modeling methods. However, optimization methods underlying data assimilation, the process of combining time ordered data with computational model (based on dynamical systems) to learn hidden states and unknown parameters, also deserves attracting similar level of interest. Data assimilation finds a large spectrum of applications ranging from geophysics/climatology to biophysics and beyond. This paper analyzes second-order optimization methods underlying data assimilation. For this purpose, results obtained with representative datasets are being considered.

3 - Forecasting with Periodic Autoregressive Model and Support Vector Regression

Ku Ishida, Osaka University, Suita, Osaka, Japan, Hiroshi Morita

This study aims to predict seasonal data by using a periodic autoregressive model. We consider to perform feature selection and parameter estimation simultaneously by second-order cone optimization. Then we combine support vector regression to adjust residuals of a periodic autoregressive model by cross-validation criterion.

4 - A Revisit to Bayesian Model Averagingin Forecasting Influenza with Google Search Queries

Hao Pan, City University of Hong Kong, Hong Kong, Hong Kong, haopan2-c@my.cityu.edu.hk, Yang Zhao, Kwok Leung Tsui

Forecasting problem is one of the crucial considerations in the subject of epidemiology, especially in dealing with the influenza data with internet search queries. It's known that there is no single method perform best on all types of data, bearing their unique advantages and limitations. Under this circumstance, there has been an increasing interest in ensemble learning approaches to model assimilation for achieving better forecasting performance, typically by the Bayesian model averaging. In this work, we focus on the statistical properties of Bayesian model averaging in the forecasting problem. Additionally, we conduct a comparative study using the ILI-GOPC data in the U.S. and Hong Kong.

■ SD04

CC- Room 204

Data Mining for Quality: Improving Processes, Businesses, Communities, and the Globe.

Sponsored: Data Mining

Sponsored Session

Chair: Romulo Ely, Rutgers University

Co-Chair: Mehmet Turkoz

1 - Weighted Bayesian Support Vector Data Description

Mehmet Turkoz, Assistant Professor NTT, Rutgers University, Piscataway, NJ, 08854, United States, Romulo Ely

Support Vector Data Description (SVDD) is an important anomaly detection procedure which describes the target data with a spherically shaped boundary without needing any distribution assumption. However, the parameters of SVDD are obtained in a deterministic way for the target data and this may not be realistic in most of the real-life applications. Moreover, SVDD is sensitive to the selection of trade off parameter. To overcome these problems, we introduce a weighted Bayesian SVDD procedure by utilizing k-nearest neighbors based novel procedure to obtain the weight of each datum. We demonstrate the superiority of the proposed method by using various simulated and real-life data sets.

2 - An Inner Approximation-based Optimal Design Algorithm to Generate Experimental Points for Nonconvex Design Space

Mehmet Turkoz, Rutgers University, 16 Rachel Terrace, Piscataway, NJ, 08854, United States, turkoz@scarletmail.rutgers.edu, Akin Ozdemir

Traditional experimental designs are effective to generate experimental points under standard design spaces, such as cube or sphere. However, for a nonconvex design space, traditional experimental designs are not appropriate due to nonstandard design conditions. The aim of this paper is to develop a new algorithm based on an inner approximation approach for nonconvex design space. In addition, the proposed algorithm efficiently produces experimental points for nonstandard experimental situations. It is also provided a fair comparison of the performance of the proposed algorithm. In addition, numerical examples are presented to illustrate the proposed method.

3 - "Zooming Out the Map": Quality Manufacturing Applied to Input-output Analysis

Romulo Ely, MSIS - Rutgers Business School, Piscataway, NJ, 08854, United States, romulo.ely@rutgers.edu, Mehmet Turkoz

Although input-output (IO) databases (DB) are periodically produced by governamental institutions around the globe, non-governmental research groups are constantly building new databases. They adapt the DBs to their particular cases including estimating multi-regional IO DBs. Our work is applied to both cases. However, we understand that benefits are easily observed in particular cases such as the estimation of waste sectors and energy efficiency scenarios. We assess the replication of methods such as support vector data description into the field of IO analysis. Sectors where the aggregation is high are naturally more challenging to be treated. We suggest an approach to deal with such cases.

4 - How to Increase Out-of-home Advertising Ratings and Efficiency with Computer Vision and Deep Learning Methods

Marcus Studart, CR, San Marino, CA, United States, Romulo Ely

Quality improvement problems are usually applied to manufacturing processes. We squeezed and stretched the traditional approach, re-shaping and driving it to a unique type of industry: advertising. We enhance the capability to deliver the message to potential consumers by reducing the number of unsuitable receivers and raising the number of suitable receivers. Advertisings delivered to unsuitable receivers are like defective products, translated into a waste of resources. By using computer vision and deep learning methods in this work, we improve the efficiency of the message delivered by raising the rate of reaching the target audience

5 - Shape Theory and Topological Statistics

Kemal Gursoy, Assistant Professor, Rutgers University, 111 North 9th Avenue, Piscataway, NJ, 08904, United States, kgursoy@business.rutgers.edu

Normal 0 false false false EN-US X-NONE X-NONE The known methods of geometry and topology are now investigated to supplement and provide new tools to use for large scale of data. In this work shape manifold and manifold estimation would be investigated for possible applications.

■ SD05

CC- Room 205

Data Science for Complex Data in Healthcare

Sponsored: Data Mining

Sponsored Session

Chair: Nathan Gaw

1 - Statistical Methods for Quantifying Phenotypic Heterogeneity

Kevin Leder, University of Minnesota, Minneapolis, MN, 55455, United States, lede0024@umn.edu

An important problem when designing cancer treatment is understanding the heterogeneity of the cancer cellular population. While genomic methods can identify subpopulations, there are several shortcomings to such approaches. In particular, one is often more interested in phenotypic heterogeneity as opposed to genotypic heterogeneity. In this work, we develop a statistical method that uses easily obtained experimental data to quantify phenotypic heterogeneity in the cellular population. This method is demonstrated on experimental and simulated data. Based on joint work with J. Foo, A. Frigessi, A. Kohn-Luque and E. Ødegaard.

2 - Network-based Multimodal Physiological Data Fusion for Characterizing Dynamic Interactive Patterns

Miaolin Fan, Northeastern University, 360 Huntington Avenue, Boston, MA, 02115, United States, fan.mi@husky.neu.edu, Chun-An Chou

In this study, we aim to characterize the dynamic interaction of human body as a complex system present a new multimodal data fusion method. Representing the multimodal interactive patterns using network models, the underlying dynamics of interactions among the brain and peripheral physiological responses to different emotional states are modeled by joint recurrence plots and temporal network metrics. Our method was applied to a bench mark dataset (DEAP) for a three-level emotion classification task of valence and arousal using temporal network-based features. The results demonstrate the capability of our multimodal information fusion model at the signal level.

3 - Applications of Finite- and Infinite-horizon Markov Decision Processes for Robust Medical Decision-making

Vinayak Ahluwalia, University of Michigan, Ann Arbor, MI, 60026, United States, vahluw@umich.edu, Lauren N. Steimle, Brian T. Denton

Markov decision processes (MDPs) are models for sequential decision-making that inform decision making in many fields, including the treatment of chronic diseases. However, MDPs are subject to parameter ambiguity because parameters estimated from different data sources may lead to different recommendations. A study of this problem for solving finite-horizon MDPs to optimality succeeded with a branch-and-bound approach, so we extend the study to infinite-horizon MDPs and recommend algorithmic designs that minimize computation time. We use a computational study that demonstrates our algorithm's effectiveness on random test instances and a previously published model for HIV treatment.

4 - Feature and Instance Selection in Semi-supervised Learning for Smartphone-based Telemonitoring of Parkinsons Disease

Nathan B. Gaw, Arizona State University, Tempe, AZ, 85258, United States, ngaw1@asu.edu, Jing Li

Monitoring Parkinson's Disease (PD) with mobile devices can greatly affect treatment outcomes. Activity collected from smartphones can be transformed to useful features that can help better understand characteristics of the disease and monitor disease progression. We introduce a first-of-its-kind semi-supervised feature selection algorithm for prediction of PD severity using data collected from smartphones. This approach uses particle swarm optimization (PSO) for selection of smartphone-based telemonitoring features, and a graph-based sampling method that reduces the computational time by selecting a smaller-representative subset of the larger training data population.

5 - Developing Personalized Forecasts of High- and Normal-tension Glaucoma Progression using Kalman Filtering

Luke DeRoos, University of Michigan, Ann Arbor, MI, 48104, United States, lkbruski@umich.edu, Koji Nitta, Mariel Sofia Lavieri, Mark P. Van Oyen, Pooyan Kazemian, Chris Andrews, Kazuhisa Sugiyama, Joshua Stein

Machine learning techniques like Kalman filtering can provide personalized and dynamically-updated forecasts of glaucoma progression trajectories. We trained, tested, and validated a Kalman filter that can predict changes in mean deviation over a 5-year time horizon at different target intraocular pressures (IOP) for patients with high- and normal tension glaucoma. Clinicians and patients can use these personalized menus of target IOP to help guide management decisions.

■ SD06

CC- Room 209

Data-Driven Decision Making in Supply-Chain Management

Sponsored: Data Mining

Sponsored Session

Chair: Karca Aral

1 - Under the Same Roof: Value of Shared Living in Airbnb

Yao Cui, Cornell University, Ithaca, NY, 14853, United States, yao.cui@cornell.edu, A. Yesim Orhun, Ming Hu

An important difference between lodging sharing economy marketplaces and traditional hotels is that the guest may be sharing the property with the host, which blurs the line between economic and social exchanges. In this paper, using Airbnb as a relevant application, we study how the social exchanges affect transaction prices in a sharing economy. We first offer empirical evidence that the guest's desire to stay with the host impacts transaction prices. The empirical evidence thus suggests that the guest may obtain a utility from staying with the host, which we term the social utility. We then theoretically investigate the implications of social utility for the sharing economy stakeholders.

2 - The Effect of Congestion and Queueing on Primary and Ancillary Product Sales

Ozge Sahin, Johns Hopkins University, Baltimore, MD, 11222, United States, ozge.sahin@jhu.edu, Ricard Gil

Businesses rely on their ancillary product sales in addition to primary goods to remain viable and profitable, in a congestion prone environment, understanding the effect of congestion on primary and secondary good sales is crucial. Using transaction-level data from a UNESCO World Heritage Site in Southern Europe, we investigate the impact of queuing and congestion on primary good sales and ancillary product sales.

3 - Sourcing Strategy under Financial Distress: Evidence From a Natural Experiment

Karca Aral, Syracuse University, Syracuse, NY, 13244, United States, Erasmo Giambona

We study financially distressed firms' sourcing strategy, both analytically and empirically. Using a difference-in-difference setting we find that firms near financial distress shifted to multi-sourcing following an increase in the protection of suppliers in case of buyer's bankruptcy. In line with our theory predictions, we also find that increasing supplier protection leads to an increase in buyer firms' performance (as measured by number of customers, sales, operating margin, and firm value).

4 - Sharing Demand Forecast with Retailer under Upstream Competition

Aditya Jain, Baruch College, Zicklin School of Business, New York, NY, 10010, United States, aditya.jain@baruch.cuny.edu

We analyze demand information sharing behavior of two competing manufacturer with a retailer. We show that by not sharing information a manufacturer ends up inflating its wholesale price as well as that of the competing manufacturer who may be sharing information. When product substitutability is low, this inflation increases the double marginalization and hurts all parties. However, when product substitutability is high, this inflation benefits manufacturers by allowing then to offset downward pressure on wholesale prices. Thus, in equilibrium the manufacturers share information in the former case, but do not share information in the latter.

■ SD07

CC- Room 210

Data Mining with Healthcare Applications

Sponsored: Data Mining

Sponsored Session

Chair: Eyyub Kibis

1 - Predicting and Preventing Patient No-show Through Bayesian Decision Support Tool.

Serhat Simsek, Montclair State University, Montclair, NJ, 36830, United States

Patients who miss their appointments (no-shows) create difficulties for medical providers. No-shows reduce revenues and impair the delivery of quality healthcare. We employed Random Forest, Logistic Regression, Artificial Neural Network and their combinations (ensemble learning) to predict whether a patient will be a no-show. With public data, our results can be compared to other approaches easily. We also developed a web application that allows efficient appointment scheduling and thus can be used by clinics to reduce no-show rates while increasing the clinic's productivity.

2 - Stochastic Optimization Model with Bayesian Network Update: The Case of Breast Cancer Chemotherapy Treatment

Kazim Topuz, Assistant Professor of Business Analytics, University of Tulsa, Tulsa, OK, 74104, United States, kazim-topuz@utulsa.edu, Eyyub Yunus Kibis, Ozlem Cosgun

Machine learning algorithms and optimization models have been utilized to complement clinical treatment for breast cancer for the last decades. However, the heterogeneous nature of cancer along with patient-related factors increases the level of stochasticity in cancer treatment models. This study determines the optimal chemotherapy dosage and frequency for stage-II breast cancer patients by integrating Bayesian belief networks into a mixed integer-programming model. Results suggest that there is no rule-of-thumb treatment method; however, dosage and frequency should be adjusted based on prognostic factors.

3 - Aggregating Machine Learning Techniques for Predicting Diabetes in Imbalance Data

Tahir Bachar Issa, Aubun University, Auburn, AL, United States

In this talk, I will present a method based on aggregating independent machine learning techniques to combat class imbalance in binary classification. I first compare ensemble learning techniques using area under PR curves and show that Stochastic Gradient Boosting and Random Forest are the bests in this order. Next I will show that aggregating independent machine learning techniques such as Logistic Regression, Random Forest and Stochastic Gradient Boosting is superior to Random Forest and Stochastic Gradient Boosting in term of specificity and sensitivity. Finally I will show aggregating dependent techniques such as Trees and Random Forest does not improve the classification.

4 - Prediction of Patient Heterogeneous Drug Dispensing Behavior Using Finite Mixture Approach

Zhouyang Lou, Purdue University, West Lafayette, IN, 47904, United States, zlou@purdue.edu, Nan Kong

Some anticholinergic drugs are harmful, causing cognitive impairment, particularly to the elderly with multiple chronic conditions, and mental disorders. Anticholinergic burden (ACB) score is used to measure the harmfulness. To help pharmacists prevent patients' problematic drug use and alert physicians, we use pharmacy claims data to develop a prognostic model for predicting the heterogeneous patient ACB score trajectory. We use a finite mixture approach with incorporation of random effects to account for the unobserved heterogeneity.

5 - Do Analysts Mislead Medical Practitioners? A Comprehensive Analytics Technique to Better Detect Non-surviving Cancer Patients

Eyyub Yunus Kibis, The College of Saint Rose, Albany, NY, 12203, United States, Serhat Simsek, Ali Dag

Analysis of survival times of cancer patients is crucial for medical practitioners to determine possible outcomes and make better future-plans for the patients. In the literature, it is common to see employment of machine learning algorithms to predict survivability of cancer patients. We detected the common misleading methodology that has been used in the literature in predicting the surviving and non-surviving cancer patients and propose a comprehensive modeling technique that overcomes the issue of misprediction of survival. In order to illustrate the issue and its solutions, the comprehensive model is applied on rectum cancer data and results are validated with SEER breast cancer dataset.

■ SD08

CC- Room 211

Interpretable Machine Learning

Emerging Topic: Artificial Intelligence & Machine Learning

Emerging Topic Session

Chair: Tong Wang, University of Iowa, Iowa City, IA, 52245, United States

1 - Faithful and Customizable Explanations of Black Box Models

Himabindu Lakkaraju, Postdoctoral Fellow/Assistant Professor, Harvard University, Cambridge, MA, United States, hlakkaraju@hbs.edu

As predictive models increasingly assist human experts (e.g., doctors) in day-to-day decision making, it is crucial for experts to be able to explore and understand how such models behave in different feature subspaces in order to know if and when to trust them. To this end, we propose Model Understanding through Subspace Explanations (MUSE), a model agnostic framework which provides customizable and faithful explanations of any given black box. Experimental evaluation and user studies demonstrate that our approach can generate highly compact, easy-to-understand, yet accurate explanations.

2 - Focused Concept Miner (FCM): An Interpretable Deep Learning for Text Exploration

Dokyun Lee, Carnegie Mellon University, Tepper School of Business, Pittsburgh, PA, 15213, United States, Dokyun@cmu.edu, Emaad Manzoor, Zhaoqi Cheng

We introduce the Focused Concept Miner (FCM), an interpretable deep learning text mining algorithm to (1) automatically extract interpretable “concepts” from text data, (2) “focus” the mined concepts to explain any existing user-specified business outcomes, such as purchase conversion (linked to reviews read) or crowdfunding success (linked to project descriptions), and (3) quantify the correlational relative importance of each mined concept for business outcomes, along with their relative importance to other user-specified explanatory variables. Compared to existing methods that partially achieve FCM’s goals, FCM achieves higher interpretability and predictive performance.

3 - Hybrid Machine Learning: When an Interpretable Model Collaborates with a Black-box Model

Tong Wang, University of Iowa, Pappajohn Business Build, Iowa City, IA, 52245, United States, tong-wang@uiowa.edu

We find an interpretable substitute for a given black-box model on a subset of data where a black box is (nearly) overkill. This way, on this subset of data, the model gains complete interpretability and transparency, which is obtained at minimal cost or no cost of the predictive performance. Under this framework, we develop Hybrid Rule Sets (HyRS) model that uses decision rules to capture the subspace of data where the rules are as accurate or almost as accurate as the black-box provided. HyRS is agnostic to the black-box model. To train a HyRS, we devise an efficient search algorithm that iteratively finds the optimal model and exploits theoretically grounded strategies to reduce computation.

4 - Optimal Classification and Regression Trees

Jack Dunn, Interpretable AI, Cambridge, MA, 02141, United States, Dimitris Bertsimas

Decision trees have been one of the most widely used approaches in machine learning across industry and academia, due in large part to their interpretability. However, this interpretability comes at a price—the performance of classical decision tree methods is typically not competitive with state of-the-art methods. We present Optimal Classification and Regression Trees, a novel and tractable method that produces decision trees that deliver interpretability and state-of-the-art performance simultaneously. We show how the interpretability of these trees has led to transformational impact with a variety of cases in healthcare, insurance, financial services, cybersecurity, and more.

5 - Interpretable AutoML for Mission Critical Supply Chain Planning

Chantal Bisson-Krol, Kinaxis, Ottawa, ON, Canada

We introduce how we are using AutoML in our software at Kinaxis, a software company in the supply chain space based in Ottawa. Machine Learning of course is all the rage in industry, so we have had considerable demand from our customers for Machine Learning powered solutions. Our users are supply chain experts, we empower them to seamlessly benefit from Machine Learning by applying AutoML principles while at the same time ensuring interpretability of models and providing explainability of predictions which helps in establishing trust in users with limited or no Machine Learning experience.

■ SD09

CC- Room 212

Business Analytics and AI

Sponsored: Artificial Intelligence

Sponsored Session

Chair: Wangcheng Yan

1 - Chasing Total Solar Eclipses on Twitter

Yunhe Feng, University of Tennessee, Knoxville, TN, United States, yfeng14@vols.utk.edu, Wenjun Zhou, Qing Cao

With the popularity of social networks, big social data analytics are creating value in various applications, such as discovering trends, monitoring public emotions, and identifying human mobilities. In this paper, we take the opportunity of The 2017 Great American Eclipse, a once-in-a-lifetime event, to look into the potential social, emotional, and human movement impacts of a single event at a national level. We collected over five million English eclipse-mentioned tweets in a real-time manner using Twitter Streaming APIs. Then we profiled spatiotemporal distributions, extracted both hashtagged and latent topics, analyzed emotions, and revealed eclipse-chasing travel patterns.

2 - Context-aware Energy Disaggregation

Yuyue Chen, Drexel University, Philadelphia, PA, United States, Chuanren Liu

When data is collected at aggregated levels, one big challenge is to disaggregate the data into significant constituents to support fine-grained analysis. We develop a general framework to address this challenge and apply it for energy disaggregation. Specifically, with a single measure of household utility consumption, we aim to separate the aggregated energy consumption into measurements for specific appliances or activities. While most existing approaches are supervised with training data for good generalization performances, our framework discovers various types of inter-correlations in complex energy consumption systems to improve accuracy, robustness, and interpretability.

3 - A Machine Learning Approach to Identity the Model-based Behavior of the Mutual Fund Advisors

Wenqiang Feng, Sr. Data Scientist, HR & Block, Kansas City, MO, United States, von198@gmail.com

Mutual fund advisors in financial companies are following the models, e.g., platform codes, to trade mutual fund products. Hence, the compliance to the models is important for the financial companies. In this work, we propose a machine learning approach which is the first study to investigate the degree of model-based behavior of the mutual fund advisors. In particular, the proposed method implements a multinomial logistic regression model using PySpark, whereas the features include the information from the sale and redeem peak days of the transaction data. The evaluation results, together with positive client feedback, demonstrate the effectiveness and efficiency of our approach.

4 - Financial Performances Prediction Using Asynchronous Time Series

Zheng Zhang, University of Tennessee-Knoxville, Knoxville, TN, United States, zzhan100@vols.utk.edu, Wenjun Zhou

Many econometric and machine learning methods have been applied to financial performances predictions. However, asynchronous time series make analysis from classical theories cannot be applied directly. In this paper, we apply the traditional vector auto-regressive (VAR) model and weighted generalized elastic-net Granger (WEGEG) to forecast the financial indices based on predictors from social media and third-party platforms. We offer the financial institutions managerial suggestions when facing negative evaluations from the Internet. Moreover, we find that WEGEG performs better the state-of-art method especially when the distribution of the data is hard to be identified.

5 - Confounder Balancing for Treatment Effect Estimation

Wangcheng Yan, The University of Tennessee-Knoxville, Management Science, Knoxville, TN, 37996, United States, wyan3@vols.utk.edu, Wenjun Zhou

Causal inference, identifying the causal effect of a given treatment, is a fundamental problem in many disciplines. Randomized trials are needed to guarantee balanced confounders in two groups; However, this is often impossible, especially in high-dimensional data. In this work, we adopt and extend a new confounder balancing technique to obtain an unbiased estimation of the average treatment effect. When matching subjects by similarity in individuals’ confounders, this technique also differentiates the weights of these covariates, which is novel to existing literature. The experimental results on both synthetic and real-world data show the effectiveness and efficiency of this approach.

■ SD10

CC- Room 213

Emerging Concepts II

Sponsored: Analytics

Sponsored Session

Chair: Aaron Burciaga, Analytics2Go, Tysons, VA, 22102, United States

1 - Predicting Seizures in Critically Ill Patients with Interpretable Machine Learning

Cynthia Rudin, Duke University, LSRC / Durham, NC, 27708, United States

We have designed an interpretable machine learning model to predict seizures in critically ill patients from cEEG measurements. This model is called the 2HELPS2B score, and it is used in several hospitals. The model is a solution to a mixed-integer nonlinear program, solved with the new Lattice Cutting Plane algorithm, which combines cutting planes with branch and bound methodology. This work is the winner of the 2019 Caterpillar INFORMS Innovative Applications in Analytics Award.

2 - Machine Learning: Multi-site Evidence-based Best Practice Discovery

Eva Lee, Georgia Tech, Industrial & Systems Engineering, Ctr for Operations Research in Medicine, Atlanta, GA, 30332-0205, United States, evalee-gatech@pm.me

This study establishes interoperability among electronic medical records from 737 healthcare sites and performs machine learning for best practice discovery. A mapping algorithm is designed to disambiguate free text and to provide a unique and unified way to link content to structured medical concepts. A classification model, DAMIP, is designed to uncover discriminatory characteristics that can predict the quality of treatment outcome. We demonstrate systems usability by analyzing Type II diabetes patients and cardiovascular patients. This work is joint with the American Medical Association.

■ SD11

CC- Room 214

Applied Probability Society Best Student Paper Competition

Sponsored: Applied Probability

Sponsored Session

Chair: Amy R. Ward, University of Chicago, Booth School of Business, Chicago, IL, 60637, United States

1 - Sub-diffusive Load-Balancing in Time-Varying Queueing Systems

Gal Mendelson, Stanford University, Graduate School of Business, Littlefield 308, Stanford, CA, 94305-5015, United States

2 - Phase Transitions and Cyclic Phenomena in Bandits with Switching Constraints

Yunzong Xu, Massachusetts Institute of Technology, Cambridge, MA, 02139, United States

3 - Marrying Stochastic Gradient Descent with Bandits: Learning Algorithms for Inventory Systems with Fixed Costs

Hao Yuan, University of Michigan, Ann Arbor, MI, United States

4 - A Lower Bound on the Queueing Delay in Resource Constrained Load Balancing

Martin Zubeldia, MIT, Cambridge, MA, 02139, United States

■ SD12

CC- Room 2A

Learning and Matching

Sponsored: Applied Probability

Sponsored Session

Chair: Jussi Keppo, National University of Singapore, Singapore, 119245, Singapore

1 - Learning Manipulation Through Information Dissemination

Xinyuan Zhang, Sauder School of Business, University of British Columbia, Mochtar Riady Building, BI Z. 1 8-69, 15 Kent Ridge Drive, Vancouver, BC, 119245, Canada, xinyuan.zhang@sauder.ubc.ca, Jussi Keppo, Michael Jong Kim

We consider the problem of optimally manipulating a Bayesian learner through adaptive provisioning of information. The problem is motivated by settings in which a firm can disseminate possibly biased information at a cost, to influence the public's belief about a hidden parameter related to the firm's payoffs. For example, firms advertise to sell products. We study a sequential optimization model in which the firm dynamically decides on the quantity and content of information sent to the public. We solve the associated Bayesian dynamic programming equation and characterize the optimal manipulation policy in closed-form. We also encode the evolution of the public's belief under such manipulation.

2 - Thompson Sampling with Information Relaxation Penalties

Seungki Min, Columbia Business School, New York, NY, 10463, United States, SMin20@gsb.columbia.edu, Costis Maglaras, Ciamac Cyrus Moallemi

We consider a finite time multi-armed bandit problem, for which we develop a Bayesian framework that naturally generalizes Thompson sampling (TS). Analogous to TS that at each decision epoch pulls an arm that is best with respect to the randomly sampled parameters, our algorithms simulate the entire future reward realizations and take a corresponding best action, but in the presence of 'penalties' that prevent them from choosing an action overly optimized for a particular scenario. In construction of suitable penalty functions, we leverage ideas from the information relaxation framework that has been used to obtain performance bounds for the stochastic Markov decision processes via simulations.

3 - Misconducts in Organizations

Minglong Zhou, NUS, 1 Business Link, Singapore, Singapore, Jussi Keppo, Esa Jokivuolle

Insider misconducts has caught public attention recently. These misconducts arise partly from high-powered financial incentives that are influenced by laws, regulations, and firms own policies. In this paper, we model the interaction among lawmakers, firms, and their employees under the risk of insider misconducts. Employees, with private information, are potential cheaters. Firms interact with employees and enforce a certain level of costly monitoring. Lawmakers affect other parties' incentives by imposing legal penalties. Our model supports that middle management typically causes large-scale misconducts. We also study how the our model helps in designing effective regulations.

4 - Competition Between Two-sided Platforms under Demand and Supply Congestion Effects

N. Bora Keskin, Duke University, Fuqua School of Business, Durham, NC, 27708-0120, United States, bora.keskin@duke.edu, Fernando Bernstein, Gregory A. DeCroix

This paper explores the impact of competition between two ride-sharing platforms. Customers' and drivers' utilities are sensitive to the prices set by the platforms and to congestion in the system. We analyze and compare the equilibrium outcomes in two scenarios, one in which each driver works exclusively for a single platform ("single-homing") and another scenario in which drivers may work for both platforms ("multi-homing" or "multi-apping").

■ SD13

CC- Room 2B

Joint Session APS/MSOM: Advances in Modeling Strategy and Behavior in Queueing Systems

Sponsored: Applied Probability

Sponsored Session

Chair: Ragavendran Gopalakrishnan, Cornell University, Ithaca, NY, 14853, United States

1 - Social and Monopoly Optimization in Observable Queues

Ran I. Snitkovsky, Tel Aviv University, George Weiss 20, Tel Aviv, 6997712, Israel, ransnit@gmail.com, Hassin Refael

Naor's celebrated paper studies customer decisions in an observable M/M/1 queue where joining-customers utility is linearly decreasing with the joining position. Naor derives the optimal threshold strategies for the individuals, social planner and monopolist, and proves the monopoly optimal threshold is smaller than the socially optimal threshold, which is smaller than the individually optimal one. Studies show, based on numerical observations and/or ad-hoc proof techniques, that this triangular relation holds within various specific setups. We point out properties that imply the aforementioned result, and suggest model applications for our findings.

2 - Strategic Servers in Queuing Systems and Dynamic Games

Hung Do, University of Vermont, Burlington, VT, United States, hdo@uvm.edu

We study the dynamic games of n-server queuing systems with strategic servers under different queue designs (e.g. single queue and queue design). We then extend our analysis to the case of asymmetric servers.

3 - Pooling Queues with Strategic Servers: The Effects of Customer Ownership

Hummy Song, The Wharton School, University of Pennsylvania, Philadelphia, PA, 19104, United States, hummy@wharton.upenn.edu, Mor Armony, Guillaume Roels

We examine how the performance of pooled versus dedicated queues compares when servers are strategic and exhibit varying degrees of customer ownership. We show that the benefits of pooling are in general completely annihilated in this setting. Keeping the scope of customer ownership unchanged, the choice of queue configuration is almost irrelevant unless (i) the customer unit holding cost is so low that the system operates at high utilization and (ii) servers care more about the processing time of the customers they are currently serving than about the waiting time of their customers in queue. Under these two conditions, adopting a dedicated queue configuration yields lower throughput times.

4 - To Pool or Not to Pool: Queueing Design for Large-Scale Service Systems

Yunan Liu, North Carolina State University, Raleigh, NC, United States, yliu48@ncsu.edu, Ping Cao, Shuangchi He, Junfei Huang

There are two queue structures in service systems: pooled structure where waiting customers are organized into a single queue served by a group of servers, and dedicated structure where each server has her own queue. Although the pooled structure, known to minimize the servers' idle times, is widely used in large-scale service systems, this study reveals that the dedicated structure, along with the join-the-shortest-queue routing policy, could be more advantageous for improving certain service levels. Using a fluid model substantiated by asymptotic analysis, we provide a performance comparison between the two structures for a moderately overloaded queueing system with customer abandonment.

■ SD14

CC- Room 302

Joint Session MSOM/Practice Curated: Assortment Planning in Retail Operations

Sponsored: Manufacturing & Service Oper Mgmt

Sponsored Session

Chair: Stanley Lim, University of San Diego

1 - Improved Approximation Schemes for Sequential Assortment Optimization

Jacob Feldman, Olin Business School, Saint Louis, MO, 63108-1291, United States, jbfeldman@wustl.edu, Danny Segev

In this paper, we consider assortment optimization under the sequential MNL choice model. In this problem, the purchasing process of customers unfolds sequentially over T stages. Within each stage, the retailer selects an assortment of products to make available for purchase, with the intent of maximizing expected revenue. The caveat is that each product can be offered in at most one stage. Moving from one stage to the next, the customer either purchases one of the currently offered products according to MNL preferences and leaves the system, or decides not to make any purchase at that time. Our main contribution comes in the form of a strongly polynomial-time approximation scheme (PTAS).

2 - Scalability in Local Grocery Food Platforms: An Examination of Indirect Network Economies

Lina Wang, Arizona State University, Scottsdale, AZ, United States, lina.wang@asu.edu, Elliot Rabinovich, Timothy J. Richards

Key to the success of two-sided online platforms is their ability to increase their economic surplus by scaling simultaneously participation on both of their sides. We study this phenomenon through a structural model of indirect network economies in an online grocery platform. We estimate the number of vendors that maximizes consumers' demand and the economic surplus in equilibrium.

3 - A Generalized Markov Chain Model to Capture Dynamic Preferences and Choice Overload

Agathe Soret, Columbia University, New York, NY, 10027, United States, acs2298@columbia.edu, Vineet Goyal, Kumar Goutam

Many parametric random utility-based choice models have been considered in the literature to capture substitution. However, in these models, the probability of purchase increases as we add more options to the assortment, which is not true in many settings, because of choice overload. In this paper we address these serious limitations using a Markovian comparison model, which allows us to implicitly model the search cost in the choice process and thus model dynamic preferences and choice overload. We consider the assortment optimization problem where the underlying Markov chain is either of rank-1 (it generalizes the MNL model) or of low rank, and show it is NP-hard. We present a FPTAS in both cases.

4 - Sample Boxes for Retail Products: Bundling Experience Goods to Leverage Consumer Uncertainty

Alireza Yazdani, University of Oregon, Eugene, OR, United States, syazdani@uoregon.edu, Eren Basar Cil, Michael Pangburn

Consumers often try a few varieties of an experience product before establishing a shopping routine. Sample boxes potentially create value by helping consumers resolve their uncertainties regarding these varieties earlier and at a lower cost. In this paper, we study how firms and consumers share this added value under different market scenarios. We show that when a firm offers a sample box, consumers obtain equal or higher net expected surplus while the firm's expected profit may decrease. We also show that a firm can reverse the potential adverse profit impact of selling sample boxes by introducing an optimally specified future credit.

5 - Finding a Market for Ugly Produce: A Multiple Discrete-continuous Choice Analysis

Stanley Lim, University of San Diego, San Diego, CA, 85287, United States, stanleylim@sandiego.edu, Sanghak Lee, Sungho Park, Elliot Rabinovich

We examine demand for imperfect produce sourced from growers and sold directly to consumers via the Internet. We model consumers' multiple discrete choice and continuous consumption decisions to uncover relationships among choice, satiation effects, and utility maximization for wide assortments. We then estimate the value of assortment to improve revenues and provide guidance on inventory planning decisions.

■ SD15

CC- Room 303

New Technologies for Supply Chain Transparency

Sponsored: Manufacturing & Service Oper Mgmt

Sponsored Session

Chair: Andre Du Pin Calmon, INSEAD, Fontainebleau, 77300, France

Co-Chair: Philippe Blaettchen, INSEAD, Fontainebleau, 77305, France

1 - The Value of Operational Transparency for Supply Chain Finance and Implications for Blockchain Adoption

Nikolaos Trichakis, MIT, Cambridge, MA, 02143, United States, ntrichakis@mit.edu, Jiri Chod, Gerry Tsoukalas

We examine how blockchains, which were originally designed to provide verifiability of digital goods transactions, can provide verifiability of physical goods transactions. We identify some of the unique implementation challenges and propose ways to mitigate them. To exemplify, we describe an open-source blockchain platform we developed and one of its use cases in agricultural supply chains. We then develop a theory showing how the proposed blockchain-enabled verifiability of physical goods transactions can be leveraged by high-quality firms to signal their operational capabilities through their upstream inventory orders, and thereby finance their operations more efficiently.

2 - A Blockchain Business Model for Green Sourcing

Xi Chen, University of Michigan-Dearborn, NUS Business School, Dearborn, MI, 119245, United States, xichenxi@umich.edu, Niyazi Taneri, Guangyu Wan, Saif Benjaafar

End-consumers pay substantial price premia for green certified sustainably sourced products. We investigate whether and how the pairing of a new technology like blockchain with an access-based business model can help better address information problems in the agro-supply-chain.

3 - Searching the Road From Farm to Fork: Adoption of Information Systems for Food Traceability

Philippe Blaettchen, INSEAD, Boulevard de Constance, Fontainebleau, 77305, France, philippe.blaettchen@insead.edu, Andre Du Pin Calmon, Sameer Hasija

Food supply chains are fraught with difficulties in certifying origins and managing contaminations. Modern technologies like blockchain promise to solve this problem with unprecedented levels of visibility into complex supply networks. They are prone to large network externalities, however, and so the path toward adoption is unclear. We analyze the optimal deployment strategy of a traceability system provider and ask whether the level of traceability attained is socially optimal. Specifically, we study how the nature of the product, the structure of the supply network, and the nature of the traceability system interact in the process of adoption.

4 - Traceability in Smallholder Supply Chains

Joann de Zegher, MIT Sloan, Cambridge, MA, 02142, United States, jfz@mit.edu

Smallholder farmers in developing and emerging economies supply over 50% of global food calories. These smallholder supply chains typically operate inefficiently, are non-traceable, and are difficult to study due to their informal nature. We will discuss how we are addressing these challenges holistically through the integration of large-scale field work and optimization.

■ SD16

CC- Room 304

Joint Session MSOM/SERV OP/Practice Curated: Platform Design in Nonprofit Sector

Sponsored: Manufacturing & Service Oper. Mgmt/Service Operations

Sponsored Session

Chair: Vahideh Manshadi, Yale University, New Haven, CT, 06511, United States

Co-Chair: Irene Yuan Lo, Stanford University, Stanford, CA, 94306, United States

1 - A Mechanism Design Approach for Medical Surplus Product Allocation

Can Zhang, Duke University, Durham, NC, 27708, United States, c.zhang@duke.edu, Atalay Atasu, Turgay Ayer, Beril L. Toktay

We analyze resource allocation problems faced by medical surplus recovery organizations (MSROs) that recovers medical products to fulfill the needs of under-served regions. We propose a mechanism design approach to elicit recipients' private needs information, and show that our proposed mechanism significantly improves MSRO's value provision compared with current practice.

2 - Operational Issues in Large Jail and Judiciary Systems

Charlie Hannigan, University of Chicago Booth School of Business, Chicago, IL, United States

We perform an analysis of a large jail and judiciary system with the goal of simultaneously reducing Length of Stay (LOS) and improving outcomes for detainees. Two primary issues contribute to high LOS: a large number of outstanding warrants and detainees' trials often lasting longer than their eventual sentences require. We model the jail as a queueing network and consider the benefits of letting low-level warrants expire. We also consider a continuous time choice model of detainees' behavior to estimate detainees sentence location sensitivity and resulting optimal trial termination time.

3 - Crowdsourcing Food Recovery: A Platform Design Study

Scott Rodilitz, Yale, New Haven, CT, 06511, United States

In collaboration with a nonprofit platform that relies on volunteers to transport weekly food donations, we leverage the heterogeneity in volunteer engagement levels by allowing "one-at-a-time" volunteers to sign up for last-minute individual recoveries while letting "adopters" sign up for weekly-recurring recoveries. We show that even though adopters provide certainty, prioritizing adoption may hurt the platform in the long run. This insight stems from our empirical analysis of volunteer behavior which reveals that having more recovery options positively impacts the engagement and retention of "one-at-a-time" volunteers.

4 - Optimal Facility Selection for Epa Compliance Assurance Program

Yasaman Mohammadshahi, PhD Student, Georgia Institute of Technology, Atlanta, GA, United States, yasaman@gatech.edu, Pinar Keskinocak, Beril L. Toktay, He Wang

EPA spends tremendous budget every year to inspect the facilities for compliance with the environmental laws. In this work, we utilize a multiarmed bandit frame work to help EPA with finding the optimal selection policy.

■ SD17

CC- Room 305

Managing Service Platforms

Sponsored: Manufacturing & Service Oper. Mgmt/Service Operations

Sponsored Session

Chair: Ozan Candogan, University of Chicago, Chicago, IL, 27708, United States

1 - The Unreasonable Effectiveness of Artificial Currencies

Artur Gorokh, Cornell University, Ithaca, NY, 14850, United States, ag2282@cornell.edu, Sid Banerjee, Krishnamurthy Iyer

The use of artificial currency markets to allocate resources over time is gaining in popularity - in cloud-computing platforms, food banks, etc. Despite this, little is known about the incentives and efficiency of such mechanisms. We will describe how simple repeated single-price auctions with artificial currencies enjoy surprisingly strong performance guarantees, for a wide class of combinatorial assignment problems, and under minimal rationality assumptions. Our results provide insights into how to set endowments, tradeoffs between notions of utility and fairness; they also uncover interesting connections between artificial currencies, fair allocation, and online decision-making.

2 - Multi-objective Online Ride-matching

Hai Wang, Singapore Management University, Singapore, 178902, Singapore, haiwang@smu.edu.sg, Guodong Lyu, Wang Chi Cheung, Chung-Piaw Teo

We study the multi-period multi-objective online ride-matching problem, in which the dynamic ride-sharing platform needs to match passengers and available drivers in real time considering multiple objectives without observing future information. We develop an efficient online matching policy that balances the trade-offs between objectives in a dynamic setting and provide a theoretical performance guarantee. We prove the proposed matching policy can achieve the "target-based optimal solution" that minimizes the distance to any pre-determined multi-objective target. Through numerical experiments using real data, we demonstrate that our approach brings value to all the stakeholders.

3 - Information Inundation on Platforms and Implication

Gad Allon, University of Pennsylvania, Philadelphia, PA, 19104, United States, gadallon@wharton.upenn.edu, Kimon Drakopoulos, Vahideh Manshadi

In this paper, we study a model of information consumption where consumers sequentially interact with a platform that offers a menu of signals (posts) about an underlying state of the world (fact). We show that in the presence of uncertainty about the accuracy of these posts, and as the number of posts increases, adverse effects such as slow learning and polarization arise. Specifically, we establish that, in this setting, bias emerges as a consequence of the consumer's screening process.

4 - Optimal Commissions and Subscriptions in Networked Markets

Hongfan Chen, University of Chicago, Chicago, IL, 60615, United States, hongfan.chen@chicagobooth.edu, John R. Birge, Ozan Candogan, Daniela Saban

We consider a platform that charges commission rates and subscription fees to sellers and buyers for facilitating transactions but does not directly control the transaction prices. We shed light on how the commissions/subscriptions should be set in networked markets. We provide a tractable convex optimization formulation to calculate the revenue-maximizing commissions/subscriptions. Our results highlight the suboptimality of commonly used payment schemes, and showcase the importance of accounting for the compatibility between different user types. Under mild assumptions, we establish that a revenue-maximizing platform achieves at least 2/3 of the maximum achievable social welfare.

■ SD18

CC- Room 306

Supply Chain Innovations

Sponsored: Manufacturing & Service Oper. Mgmt/Supply Chain

Sponsored Session

Chair: Luyi Gui, The Paul Merage School of Business, UC Irvine, Irvine, CA, 92697-3125, United States

1 - Sustainability in the Fast Fashion Industry

Xiaoyang Long, University of Wisconsin-Madison, Wisconsin School of Business, Madison, WI, 53706, United States, xiaoyang.long@wisc.edu, Javad Nasiry

A fast fashion system allows firms to react quickly to changing consumer demand by replenishing inventory (via quick response) and introducing more fashion styles. In this paper, we study the environmental implications of the fast fashion business model by analyzing its implications for product quality, variety, and inventory decisions.

2 - Enhancing Prepositioning Policies for Food Aid Supply Chains: An Economic Optimization Model for Usaid Food for Peace Program's Operations

Weijia Jing, Northeastern University, Boston, MA, United States, jing.we@husky.neu.edu, Ozlem Ergun, Keziban Rukiye Tasci, Stephen Vosti

United States Agency for International Development (USAID) office of Food For Peace (FFP) runs a global humanitarian supply chain. To help the organization achieving more effective decision making for procurement and food aid distribution, we built data driven models and a supply chain tool to apply optimization methods, ensuring cost effective procurement and distribution of food aid. Through scenario analysis, we developed insights on optimal prepositioning and warehouse location selection for a merged supply chain serving both long-tern operations and emergency response.

3 - Cost Analysis in Global Supply Chains with Tariff Increases Due to Trade Wars

Yuhong He, Assistant Professor, California State University-Fullerton, Fullerton, CA, 92831, United States, yuhe@fullerton.edu, Shuya Yin

This study demonstrates how tariff increases due to trade wars affect the members in supply chain network. More specifically, we focus on the effect of cost on global supply chain and how these effects are sensitive to the nature of products, the network structure, and the approach we incorporate the cost fluctuation.

4 - Dual Sourcing Models with Stock-out Dependent Substitution

Mustafa Hekimoglu, Assistant Professor, Kadir Has University, Istanbul, Turkey, mustafa.hekimoglu@khas.edu.tr, Alan Scheller-Wolf

Motivated by an example in the aviation industry, we introduce a finite horizon dual sourcing problem with stock-out dependent substitution (DSWS) which incorporates quality difference between two suppliers. Due to nonconvexity of the multi-period model, the optimal policy appears intractable. Using a proved relation between the optimal cost of DSWS and costs of other problem types - dual sourcing without substitution and single sourcing problems, we suggest two heuristics called dual index and inverse-dual index. Extensive numerical experiments show that the dual index policy outperforms other candidate solutions by at least 7% and its optimality gap is only 4% for short planning horizons.

■ SD19

CC- Room 307

Sustainable Supply Chains and Developing Markets

Sponsored: Manufacturing & Service Oper. Mgmt/Supply Chain

Sponsored Session

Chair: Sebastian Souyris, The University of Texas at Austin, Austin, TX,United States

1 - On Last Mile Delivery in the Lake Tanganyika Region of the Democratic Republic of the Congo

Robert Montgomery, University of Chicago, Chicago, IL, United States, rmontgo0@chicagobooth.edu, Baris Ata

We study the effectiveness of strategic inventory placement in the last mile delivery context. We focus on systems with multiple modes of delivery transportation, where a high cost is associated with disruptions leading to delivery failures. The problem is motivated by work with an NGO providing preventative healthcare products to the Lake Tanganyika Region of the Democratic Republic of the Congo.

2 - Rent-to-Own Business Models in Developing Economies: An Empirical Analysis

Jose A. Guajardo, University of California-Berkeley, Haas School of Business, Berkeley, CA, 94720-1900, United States

The diffusion of technological innovations in developing economies has been facilitated by the use of rent-to-own business models, which give flexibility to customers by allowing them to make incremental payments over time. I empirically analyze an application of rent-to-own to the distribution of solar lamps in developing countries, characterizing different factors that influence operational performance.

3 - Peer Effects in the Diffusion of Solar Panels: A Dynamic Discrete Choice Approach

Sebastian Souyris, The University of Texas at Austin, Austin, TX, 10028, United States, sebastian.souyris@utexas.com, Jun Duan, Anantaram Balakrishnan, Varun Rai

We study the magnitude of economic factors and peer effects in the adoption of residential solar panels. We use a dynamic discrete choice model and perform counterfactual analysis to guide policy to incentivize adoption.

4 - Sourcing from a Self-Reporting Supplier? Strategic Communication of Social Responsibility in a Supply Chain

Tao Lu, Rotterdam School of Management, Erasmus University, Mandeville Building T09-03, Rotterdam, 3062 PA, Netherlands, Brian Tomlin

We examine whether supplier's social responsibility (SR) risk can be truthfully communicated through self-reported assessments. Adopting a cheap talk framework, we establish that truthful communication can occur if the buyer can audit (perhaps imperfectly) the supplier and the buyer's end market is sensitive to SR violations. Further, we show that the buyer may not benefit from a cheaper or more accurate audit capability.

■ SD20

CC- Room 308

Joint Session Education/Project Mgmt.: Teaching Project Management

Sponsored: Education

Sponsored Session

Chair: Nicholas G. Hall, Ohio State University, Columbus, OH, 43210-1144, United States

Co-Chair: Gary Mitchell, University of Portland, Portland, OR, 97203-5798, United States

Co-Chair: Theodore D Klastorin, University of Washington, Seattle, WA, 98195-3226, United States

Moderators

- Nicholas G. Hall, Ohio State University, Columbus, OH, 43210-1144, United States
- Theodore D. Klastorin, University of Washington, ISOM Department, Seattle, WA, 98195-3226, United States

Panelists

- Richard Wendell, University of Pittsburgh, Pittsburgh, PA, United States
- George Vairaktarakis, Case Western Reserve University, Dept of OR and OM, Cleveland, OH, 44106-7235, United States

■ SD21

CC- Room 309

Operations and Financing Interface

Sponsored: Manufacturing & Service Oper. Mgmt/iFORM

Sponsored Session

Chair: Onur Boyabatli, Singapore Management University, Singapore, 178899, Singapore

1 - Supplier Diversification under Buyer Risk

Gerry Tsoukalas, Wharton School of Business, Philadelphia, PA, 19104, United States, Jiri Chod, Nikolaos Trichakis

When should a firm diversify its supply base? Most extant theories attribute supplier diversification to supplier risk. Herein, we develop a new theory that attributes supplier diversification to buyer risk. When suppliers are subject to the risk of buyer default, buyers may take costly action to signal creditworthiness so as to obtain more favorable terms. But once signaling costs are sunk, buyers sourcing from a single supplier become vulnerable to future holdup. Our theory can help explain sourcing strategies when risk in a trade relationship originates from the sourcing firm, for example, a small-to-medium enterprise or a start-up; a setting that has eluded existing theories so far.

2 - Platform Financing

Heikki Peura, Imperial College Business School, South Kensington Campus, London, SW7 2AZ, United Kingdom, h.peura@imperial.ac.uk, S. Alex Yang, S. Alex Yang

We consider how a two-sided platform manages its supplier through financing.

3 - The Impact of Production-budget Uncertainty on Stochastic Capacity Investment

Boya Yang, Singapore Management University, Singapore, Singapore, boyayang.2015@pbs.smu.edu.sg, Onur Boyabatli, Guiyun Feng

We consider a single-product firm that invests in capacity in the presence of demand and production-budget uncertainties. We examine how the budget variability and the correlation between budget and demand uncertainties shape the optimal capacity investment decision and firm's profitability. For example, we show that higher correlation increases the optimal capacity investment and profitability. We also investigate the significance of profitability loss incurred when the budget uncertainty is ignored, as commonly observed in the literature.

4 - The Endemic Population-trust and Supply Chain Networks

Volodymyr O. Babich, Georgetown University, McDonough School of Business, Washington, DC, 20057, United States, vob2@georgetown.edu, Gilles Hilary, Ziang Wang, Jing Wu

We apply the assortive matching theory of Becker (1973) to analyse the supply chain partnerships based on the endemic population trust attribute (trust of the communities in geographies where firms operate). Using a unique dataset, we find that the durability of supply chain links decreases in the trust distance in the steady state equilibrium, but increases in the average trust outside of steady state, after shocks to supply chains (hurricanes and class action lawsuits). This evidence is consistent with the strategic complementarity of the endemic population trust in supply chains partnerships and trust's role as capital affecting supply chain resilience.

■ SD22

CC- Room 310

Energy Policy and Operations

Sponsored: Manufacturing & Service Oper. Mgmt/Sustainable Operations

Sponsored Session

Chair: Michael Galbreth, University of Tennessee, Knoxville, TN, 37996, United States

1 - Expanding Access to Rooftop Solar through Community Solar Programs

Siddharth Prakash Singh, Carnegie Mellon University, Pittsburgh, PA, United States, siddharth.p.singh@gmail.com, Owen Wu

Several states in the U.S. have instituted enabling policies to encourage the development of community solar programs, with a view to expand solar access to customers who, for instance, are renters or do not have roofs suitable for rooftop solar. Community solar arrays are much larger than rooftop arrays and, therefore, enjoy economies-of-scale. The arrays are jointly owned by a community of subscribers in the locality; these subscribers typically pay a fixed fee and reap the benefits of the portion of the array owned by them. We study the interaction between the policy environment and commercial participation in community solar.

2 - Design of Electricity Demand-response Programs

Vishal Agrawal, Georgetown University, Washington, DC, 20057, United States, vishal.agrawal@georgetown.edu, Safak Yucel

Under demand-response programs, utility firms compensate electricity customers to reduce their consumption when the aggregate demand is expected to be high. Given that customers' demand is random and unobservable to a utility firm, the firm estimates the reduction in a customer's consumption by comparing observed consumption to an administratively set baseline. We study how the existence of a baseline affects the success of a demand response program by accounting for customers' participation and demand-shifting decisions.

3 - Estimating Supply Side Parameters with Local Entrants in Renewable Energy Market

Herbie Huang, University of North Carolina, Chapel Hill, Chapel Hill, NC, United States, Herbie_Huang@kenan-flagler.unc.edu, Nur Sunar, Jayashankar M. Swaminathan

Global warming has been rising as a pressing issue. One effective way to combat the global warming is to make the renewable energy technologies more accessible. Motivated by this, we study a renewable energy market to estimate local participation behavior of providers in the market.

■ SD23

CC- Room 3A

Applications of Decision Analysis for Federal, State, Provincial, and Tribal Natural Resource Management I

Sponsored: Decision Analysis

Sponsored Session

Chair: Michael C Runge, USGS Patuxent Wildlife Research Center, Laurel, MD, 20708, United States

1 - Risk Analysis and Structured Decision Making in U.S. Forest Service Research and Management

Bruce Marcot, USFS Pacific Northwest Research Station, Portland, OR, 97208, United States

USFS has been applying risk analysis and decision science to a wide variety of research and management issues, including: monitoring and threats assessments of federally-listed and at-risk species, impacts of engineering projects on research priorities, and analysis of potential injuriousness of introduced and invasive species. I review the SDM framework, tools for each stage, topics of study to aid applying SDM to natural resource risk management.

2 - A Structured Decision Making Approach to Addressing Wild Turkey Population Declines

Kelly Robinson, Assistant Professor, Michigan State University, East Lansing, MI, United States, kfrobins@msu.edu, Angela Fuller, Michael Schiavone, Duane Diefenbach, William Siemer

Turkey (Meleagris gallapavo) populations in New York have been declining in recent years. Reducing harvest of females during fall hunting season could potentially reduce the population decline but requires consideration of biological and social concerns. We used structured decision making to incorporate the multiple objectives associated with turkey hunting, stakeholder desires, and region-specific ecological and environmental factors that could influence fall harvest. The optimal fall harvest regulation was the most conservative of those evaluated, reflecting the concerns about recent declines in turkey abundance among agency wildlife biologists and the hunting public.

3 - Habitat Conservation Decisions for an Endangered Endemic Salamander in Alabama

Conor P. McGowan, USGS Alabama Cooperative Fish and Wildlife Research Unit, Auburn, AL, 36849, United States, cmcgowan@usgs.gov, Orin Robinson, J.J. Apodaca

We applied a decision dnalysis approach to habitat conservation decisions for the Red Hills Salamander (Phaeognathus hubrichti,), a severely range limited, endangered species in Alabama. Working with stakeholders, we developed an objectives hierarchy linking land protection actions to objectives and built a model to assess habitat quality for 5814 pixels of 1 square kilometer in the salamander's range and applied acquisition costs to each pixel. We devised a value function and calculated the value of each square kilometer under alternative objective weights. The results are being used by the State to identify land owners in the most valued pixels who are willing to sell their property.

4 - Spatial-temporal Variation Impacts Optimal Decision for Management of Feral Pigs (Sus Scrofa)

Melissa Price, University of Hawai'i at Manoa, Honolulu, HI, 96822, United States

Species distribution models are commonly used in spatial conservation planning to prioritize management decisions but seasonality is often excluded from the modelling process. In this study we aimed to address how temporal changes in species distribution might affect management decisions. We found significant variation in feral pig distribution between the two seasons of data collection. Incorporating the best-fitted model for each season into a prioritization framework aimed at addressing conservation and game management objectives led to different decision recommendations by season. This study highlights the importance of incorporating temporal variation into decision analyses.

5 - Multiple Objective Spatial Optimization for Managing 254 Invasive Species Across New York State

Jennifer L. Price Tack, Postdoctoral Researcher, Cornell University, Ithaca, NY, 14853, United States, jpricetack@cornell.edu, Qinru Shi, Carrie Brown-Lima, Jennifer Dean, Carla P. Gomes, Angela K. Fuller

Invasive species management decisions are inherently spatio-temporal, highly uncertain, and require consideration of species-specific biological attributes and treatment feasibility. We used structured decision making as a framework to develop a model for the spatial allocation of management actions considering multiple species that minimizes social, economic, and environmental impacts at the lowest cost. We apply our model to the management of 254 invasive species in New York and compute the Pareto frontier using a multi-objective optimization framework. Our approach provides managers with a robust decision and highly informative output for exploring tradeoffs among the objectives.

■ SD24

CC- Room 3B

Multi-objective Optimization: Methods and Applications

Sponsored: Multiple Criteria Decision Making

Sponsored Session

Chair: Murat Mustafa Koksalan, Middle East Technical University, Ankara, 06531, Turkey

1 - Interactive Two Response Design Parameter Optimization Considering Prediction Errors and the Specification Region

Melis Ozates, Middle East Technical University, Industrial Engineering Dept, Ankara, 06800, Turkey, mozates@metu.edu.tr, Gulser Koksal, Murat Mustafa Koksalan

We present an interactive approach to search for the desired parameter settings of a decision maker (DM) for the two-response product and process design problem. Our approach utilizes response surface models having prediction errors in the performance measures. The DM considers the magnitudes of prediction errors and nonconformance to specifications in searching for the solution. To aid the DM, we provide visual aids for joint prediction regions of selected solutions plotted over lower and upper specification limits and target values of the responses.

2 - UAV Routing to Maximize Information Gain in a Monitored Environment with Time and Radar Restrictions

Erdi Dasdemir, Research Assistant / PhD Student, Hacettepe University, Hacettepe University, Industrial Eng. Depart., Beytepe Campus, Cankaya, Ankara, Ankara, Turkey, edasdemir@hacettepe.edu.tr, Rajan Batta, Murat Mustafa Koksalan, Diclehan Tezcaner Ozturk

We address UAV routing to collect information from targets in a monitored environment. The information at each target varies by time. There are multiple trajectory options between target pairs with different travel time and threat attributes. A subset of targets may be visited in a mission due to time and detection threat considerations. The problem is a combination of target selection, determination of the sequence of visited targets and trajectories to follow between target pairs. We develop heuristics as well as a mixed integer program and implement a hybrid solution approach.

3 - Representing the Nondominated Set with a Small Subset in Multi-objective Mixed-integer Programs

Ilgin Dogan, University of California Berkeley, Berkeley, CA, 94708, United States, ilgindogan@berkeley.edu, Banu Lokman, Murat Mustafa Koksalan

In multi-objective mixed-integer programs (MOMIPs), generating a set of representative points to the decision maker often rises as an important practical issue since finding all nondominated points is typically hard. We observe that the shape and density distribution of nondominated frontier may be critical in defining the desired properties of the representative subset to be generated. We develop an exact algorithm to generate a small number of nondominated points that represent the frontier with a prespecified quality level. We perform extensive computational experiments yielding the outstanding performance of our approach in terms of solution quality and efficiency.

■ SD25

CC- Room 401

Mobility and Accessibility

Emerging Topic: Humanitarian and NotforProfit Operations

Emerging Topic Session

Chair: Pascal Van Hentenryck, Georgia Institute of Technology, Atlanta, GA, 30332, United States

1 - Mobility-on-demand Versus Fixed-route Transit Systems: An Evaluation of Traveler Preferences in Low-income Communities

Xilei Zhao, University of Florida, Gainesville, FL, United States, xilei.zhao@essie.ufl.edu, Xiang Yan, Yuan Han, Pascal Van Hentenryck, Tawanna Dillahunt

Transit observers envision future public transit to be integrated transit systems with fixed-route services running along corridors and on-demand ridesharing services covering lower-density areas. A switch from a fixed-route service to an integrated mobility-on-demand transit system, however, may elicit varied responses from local residents. This paper applies the ordered logit model to evaluate traveler preferences for a proposed integrated mobility-on-demand transit system versus the existing fixed-route system, with a particular focus on disadvantaged travelers in Detroit and Ypsilanti, MI. Most respondents preferred a mobility-on-demand transit system over a fixed-route one.

2 - Last-Mile Scheduling under Uncertainty

Thiago Serra, Bucknell University, Lewisburg, PA, 02139, United States, Arvind Raghunathan, David Bergman, John Hooker, Shingo Kobori

Shared mobility is revolutionizing urban transportation and has sparked interest in optimizing the joint schedule of passengers using public transit and last-mile services. Scheduling systems must anticipate future requests and provision flexibility to be adopted in practice. In this work, we consider a two-stage stochastic programming formulation for scheduling a set of known passengers and uncertain passengers that are realized from a finite set of scenarios. We present an optimization approach based on decision diagrams. We obtain, in minutes, schedules for 1,000 known passengers that are robust and optimized with respect to scenarios involving up to 100 additional uncertain passengers.

3 - An Integrated Car-and-ride Sharing System for Mobilizing Heterogeneous Travelers with Application in underserved Communities

Miao Yu, University of Michigan, Ann Arbor, MI, 48109, United States, miaoyu@umich.edu, Siqian Shen

We consider integrated car-and-ride sharing (CRS) for Type 1 drivers who rent shared cars and Type 2 passengers who need shared rides. We propose a two-phase approach where in Phase I we determine car allocation and Type 1 drivers to accept; in Phase II we solve a stochastic mixed-integer program to match the accepted Type 1 drivers with Type 2 users, and optimize their pick-up routes under random travel time. We demonstrate the performance of a CRS system using instances based on census data. We also demonstrate the computational efficacy of our decomposition algorithm benchmarked with the traditional Benders decomposition for solving Phase II.

4 - Design of Multimodal Transit Systems

Pascal Van Hentenryck, Georgia Institute of Technology, 755 Ferst Drive NW, Atlanta, GA, 30332, United States

This presentation reviews the design of on-demand multimodal transit systems that combine fleet of small vehicles with rail and buses. The presentation reviews the challenges and potential solutions to the design of such large-scale systems.

■ SD26

CC- Room 4C-1

Best Service Science Paper III

Sponsored: Service Science

Sponsored Session

Chair: Ming-Hui Huang, National Taiwan University, Taipei, 10617, Taiwan

1 - The Effect of User-generated Content on Hotel Demand under a Competitive Framework

Sanghoon Cho, University of South Carolina, Columbia, SC, United States, Pelin Pekgun, Ram Janakiraman, Jian Wang

We investigate the impact of user generated content on hotel performance as captured by actual hotel bookings. We propose and estimate a consumer learning model that focuses on the effect of review sentiment on hotel demand taking into account the effect of competition and hotel prices. Drawing on prospect theory, we cast the competitive perception spillover effects in the form of gains and losses in review sentiment, and find that the relative negative sentiment has more influence on bookings than the relative positive sentiment.

2 - Call to Duty: Just-in-time Scheduling in a Restaurant Chain

Masoud Kamalahmadi, Indiana University, Bloomington, IN, 47405, United States, Qiuping Yu, Yong-Pin Zhou

Using a dataset of 1.4 million transactions from 25 stores of a full-service casual dining restaurant chain in the US, we study how just-in-time (JIT) scheduling (i.e., short-notice and real-time schedules) impacts worker productivity. We show that short-notice schedules do not harm server productivity but real-time schedules do, by 4.4%. We then propose an analytical scheduling model that accounts for both the value of staffing flexibility created through JIT scheduling and its impact on server productivity to inform the firm whether and how to use JIT scheduling to improve profitability. We show that restaurants can increase their profit by about 4.5% by incorporating our behavioral insights.

3 - Value of High-quality Logistics: Evidence from a Clash Between SF Express and Alibaba

Ruomeng Cui, Emory University, Decatur, GA, 30033, United States, ruomeng.cui@emory.edu, Meng Li, Qiang Li

In this research, we explore the extent to which customers value a high-quality delivery experience when shopping online. We exploit a natural clash between SF Express and Alibaba which resulted in Alibaba unexpectedly removing SF Express as a shipping option from Alibaba's retail platform for 42 hours in June 2017. We find that the removal of the high-quality delivery option from Alibaba's retail platform reduced sales by 14.56% during the clash, increased the contribution of long-tail to total sales by 3%, but did not impact the variety and logistics rating of sold products. We also find that the removal of SF Express is more obstructive for star, expensive and less-discounted products.

4 - The Armchair Decision: on Queue-length Information When Customers Travel to a Queue

Ricky Roet-Green, University of Rochester, Simon Business School, Rochester, NY, 14627, United States, ricky.roet-green@simon.rochester.edu, Refael Hassin

A common assumption in queueing models is that if a customer decides to join the queue, joining is instantaneous. This assumption does not fit real-life settings, where customers have to travel to a service facility, and while traveling, the queue length might change. Motivated by this realistic setting, we study how queue-length information prior to traveling impacts customers' decision to travel. We compare two models: when customers observe the service-queue state prior to traveling, and when no such information is available. We show that when system congestion is high, the provider can increase throughput by disclosing the queue-length information.

5 - Learning Personalized Product Recommendations with Customer Disengagement

Divya Singhvi, MIT, Cambridge, MA, 02139, United States, Hamsa Bastani, Pavithra Harsha, Georgia Perakis

We consider the problem of personalized product recommendations when customer preferences are unknown and customers decide to stay on the platform based on the quality of recommendations. We prove that bandit learning algorithms over-explore and the greedy policy under-explores in this regime. We propose a new learning algorithm that carefully balances the exploration-exploitation tradeoff in this setting and provably outperforms state-of-art algorithms in this setting.

6 - Decision Forest a Nonparametric Approach to Modeling Irrational Choice

Yi-Chun Chen, UCLA Anderson School of Management, Los Angeles, CA, United States, yi-chun.chen.phd@anderson.ucla.edu, Velibor Misic

An increasing amount of research has revealed that customers are not necessarily rational when making decisions. In this paper, we study a new nonparametric choice model that relaxes assumption of weak rationality. In this model, each customer type is associated with a binary decision tree. Together with a distribution over customer types, the resulting model, called decision forest, can represent any customer choice model, including those inconsistent with weak rationality. We theoretically characterize the depth of the forest needed to fit a data set and propose an efficient estimation method. We further demonstrate the effectiveness of the model on both synthetic and real transaction data.

■ SD27

CC- Room 4C-2

Service Pricing

Contributed Session

Chair: Mustafa Dogan, Carnegie Mellon University, Pittsburgh, PA, 15213, United States

1 - Frills and Product Pricing with Online Reviews

Yao Zhang, Northeastern University, Shenyang, China, yzhang@mail.neu.edu.cn, Cui Zhao

In this paper, we investigate the joint optimization of product pricing and frill decisions for a competitive online retailing market. We develop four game-theoretic models for the constructed frill scenarios, respectively. By comparing the equilibrium decisions under the four scenarios, we determine the optimal product price and frill strategies.

2 - Pricing Ancillary Service Subscriptions

Ruxian Wang, Johns Hopkins University, Carey Business School, Kensington, MD, United States, ruxian.wang@jhu.edu, Maqbool Dada, Ozge Sahin

We investigate heterogeneous customer choice behavior in the presence of main products, ancillary services with options of pay-per-use and subscription, as well as the outside option. Ancillary service subscription can help firms to better price-discriminate heterogeneous customers through different subscription decisions and subsequent purchase behavior.

3 - Strategic Timing and Dynamic Pricing in On-demand Platforms

Mustafa Dogan, Carnegie Mellon University, Pittsburgh, PA, United States, mdogan@andrew.cmu.edu, Alexandre Jacquillat, Vibhanshu Abhishek

We design a dynamic pricing and allocation mechanism for service provision in on-demand platforms facing demand stochasticity, heterogeneity across price-sensitive and time-sensitive customers, and information asymmetry. Time is a strategic device to dynamically manage the demand-capacity imbalances and to provide discriminated service levels. The optimal mechanism depends on the strength of customer heterogeneity and the time preferences of price-sensitive customers. The proposed mechanism increases platform profits as compared to dynamic pricing policies and to static screening menus. We show that optimal prices are not monotonic with demand; higher demand may trigger lower prices.

4 - Pricing Service Maintenance Contracts Using Predictive Analytics

Laurens Deprez, KU Leuven, Leuven, Belgium, Katrien Antonio, Robert Boute

Under a full-service agreement all maintenance costs are covered over a predetermined time horizon in exchange for a fixed premium. The stochastic and machine-dependent nature of the maintenance costs renders the determination of the premium challenging for the service provider. Inspired by insurance pricing, we use predictive analytics to determine the break-even price based on machine-dependent characteristics. We build a simulation engine to mimic the maintenance occurrences and their costs in a real environment and show the economic value of a differentiated pricing strategy.

5 - The Role of Gender and Excessive Financial Behavior in Financial Services

Dominik Piehlmaier, Assistant Professor of Marketing, University of Sussex, Brighton, United Kingdom

This study with more than 9,000 observations assesses the impact of gender on reckless financial behavior. It differentiates between investors who make their decisions independent of others and those who seek outside advice. Within the group of isolated decision-makers, women are equally likely to engage in reckless financial behavior and have a higher propensity to be negatively affected by multiple investment fees compared to men. These female investors are equally likely to believe that their portfolio will outperform the market, have a comparable propensity to make ad-hoc predictions of the average return of the S&P 500 over the course of the next 10 years, and are just as likely to trade on margin.

■ SD28

CC- Room 4C-3

Opportunities and Challenges in Emerging Services Technologies

Sponsored: Service Science

Sponsored Session

Chair: Dobin Yim, George Washington University, DC, United States

1 - Free or Fee the Values of Certifications in Online Labor Market

Qiang Gao, Baruch College, City University of New York, New York, NY, 10010, United States, Mingfeng Lin

Many online labor platforms implemented certification mechanism in order to increase worker contract winning probability. However, there is little empirical research on its impact on buyers' contract-awarding decision. Using data from one of the largest online labor markets, we first examine the effects of certification on worker's contract winning probabilities. Cost of certification may be the major factor that affects the effectiveness of certification. A policy change that made the certification test free on the studied platform provides a good opportunity for us to explore this relationship. We finally investigate whether certification reveals the workers' quality.

2 - Carrot or Stick? Check the Weather First: The Effect of Weather on Mobile-based Interventions for Physical Activity

Sanghee Lim, Assistant Professor, Johns Hopkins Carey Business School, Baltimore, MD, 21202, United States, lim.sanghee@jhu.edu, Nakyung Kyung, Byungtae Lee

In this study, we provide the results of a field experiment that examines the effectiveness of different mobile-based interventions (i.e., gain, loss, and neutral framed) in different weather conditions. Our results show the varying effects of gain- and loss-framed intervention depending on the weather: a loss-framed message is more effective on sunny days, while a gain-framed message is more effective on cloudy days. Based on the mood as resource theory, we provide a theoretical discussion that explains our results and advances our

3 - Making the Case: Describing the Value of the Internet of Things in Smart Cities

Joseph Taylor, Assistant Professor, California State University, Sacramento, Sacramento, CA, United States, joseph.taylor@csus.edu, Zafor Ahmed, Sadaf Ashtari, Ramakrishna Dantu, Evren Eryilmaz

The smart city industry is projected to be a $400 billion market by 2020, with 600 cities around the globe expected to generate 60% of the world's GDP by 2025 (Maddox, 2018). Although efficiency, accuracy, automation are often described as the benefits of IoT in smart city interventions, the process of value generation and its theoretical underpinnings are still emerging. This study draws from the organizational information processing view (OIPV) and Sociomaterialism theory to offer a systematic framework to researchers in this emerging area. Our findings and IoT use-cases offer valuable guidelines for policy-makes involved with smart-city initiatives.

■ SD29

CC- Room 4C-4

Market Design and Societal Concerns

Sponsored: Auction and Market Design

Sponsored Session

Chair: Juba Ziani, Caltech, Pasadena, CA, 91106, United States

Co-Chair: Katrina Ligett

1 - Downstream Effects of Affirmative Action

Juba Ziani, Caltech, Pasadena, CA, 91106, United States, jziani@seas.upenn.edu, Sampath Kannan, Aaron Roth

We study a two-stage model: students are 1) admitted to college on the basis of an entrance exam (a noisy signal about their qualification/type), then 2) students who were admitted to college can be hired by an employer as a function of their college grades (a noisy signal of their type). Students are drawn from one of two populations with different type distributions. We study what kinds of fairness goals can be achieved by the college by setting its admissions rule and grading policy. We show that both goals we consider can be achieved when the college does not report grades. On the other hand, we show that they are impossible to achieve even in isolation when the college uses an informative grading policy.

2 - Incentivizing Fair Data Collection

Rachel Cummings, Georgia Tech, Atlanta, GA, 30332-0205, United States

A surveyor wants to accurately estimate a statistic on a population, but individuals belong to different subpopulations with differing response rates and failing to collect representative data can lead to inaccurate estimation. Alternatively the surveyor may require accurate estimation on every subpopulation, to ensure that minority subpopulations are not ignored. The surveyor can choose an investment level for each subpopulation to increase the response rate, e.g., by expending resources to better sample these people or compensate people for their responses. We study the optimal investment level in each subpopulation, and the corresponding trade-off between budget and fairness/accuracy.

3 - Statistical Fairness in Equilibrium

Christopher Jung, University of Pennsylvania, Philadelphia, PA, United States

We consider the application of machine learning in the criminal justice system and its implications for fairness through a micro-economic lense. We consider a model in which different populations have different distributions over outside options and decide whether or not to commit a crime by evaluating the value of their outside option together with the false positive/negative rates of the criminal justice system. Thus, modifying the system can change the underlying crime rates for both populations and can have unexpected effects on the posterior probability of criminality conditioned on the prediction of the learning algorithm. We study questions both of accuracy and fairness in this model.

4 - A Short-term Intervention for Long-term Fairness

Lily Hu, Harvard University, Cambridge, MA, United States, lilyhu925@gmail.com, Yiling Chen

We show that disparate labor market outcomes between social groups may be immovable even when hiring decisions are bound by an input-output notion of fairness. We construct a dynamic reputational model of the labor market that illustrates the reinforcing nature of asymmetric outcomes resulting from divergent accesses to resources. We adopt a dual labor market composed of a Temporary Labor Market, in which firms must hire to ensure statistical parity of workers granted entry into the pipeline, and a Permanent Labor Market, in which firms hire top performers as desired. This restriction induces an equilibrium that can Pareto-dominate those arising from strategies that employ agroup-blind criterion.

■ SD29a

CC- Room 400

Health Care, Modeling and Optimization IV

Contributed Session

Chair: Nasibeh Zanjirani Farahani, Mayo Clinic, Rochester, MN, 55902, United States

1 - Diabetes Risk Modeling by Copulas Approaches

Hsing Luh, National Cheng Chi University, Taipei, Taiwan, slu@nccu.edu.tw

We derive the distribution of survival time under different risks of diabetes complications. In particular, we study the property of survival copulas and discuss the dependence measures associated with this construction.

2 - A Data Analytics Approach to Characterize Statin Use Among Prediabetic Patients

Alexandra Gentile, University of Arkansas, Fayetteville, AR, United States, amgentil@uark.edu, Shengfan Zhang

Prediabetes is characterized by elevated glucose levels putting patients at risk for Type 2 diabetes. Many patients are also at risk for cardiovascular disease (CVD). An effective treatment for CVD prevention is statin therapy; however, research has linked statins with the development of diabetes, causing controversy in the medical community as to whether prediabetic patients should be prescribed statins for CVD risk. In this study, we employ machine learning techniques using the National Health and Nutrition Examination Survey data to explore the association between patient characteristics and statin prescription for prediabetic patients.

3 - Machine Learning Approach for Building Reliable Integrated Emergency Medical Service Networks for Trauma Patients

Nasibeh Zanjirani Farahani, University of Missouri, Columbia, MO, United States, Moein Enayati, Salman Ahmad, Mihail Popescu, James Noble

Trauma injuries are a leading cause of death in the US, while reliable and efficient Emergency Medical Services (EMS) can increase the survival rate of such patients drastically. This research presents a machine learning approach to reduce the prehospitalization time, in medical transport networks. Innovative on-site evaluation of the trauma patients' health condition along with the performance measure of the trauma centers/intermediate clinics driven from EMS historical data is proposed as the key for better allocation of resources.

4 - An Algorithm of ICD-10-cm Auto-encoding for Inpatients with Comorbidity and Complication

Sheng-I Chen, Assistant Professor, National Chiao Tung University, HsinChu, Taiwan, sichen@nctu.edu.tw, Wei-Ting Hsu, Hsiu-Mei Wei, Ying-Ying Yang, Hao-Min Cheng, Ling-Yu Yang

ICD encoding influences the reimbursement of treatment claimed from healthcare insurance programs. It relies on specialists to reexamine information about the diagnosis and treatments of patients. We aim to facilitate such an operation by developing an algorithm to examine ICD-10-CM codes for multi-disease patients complicated by diabetes mellitus. We formulate the encoding decision as a network optimization problem using the extracting information of the diagnosis report and ICD code definitions. To tackle missing information in the diagnosis report, we develop a procedure to cluster similar diseases and then select to default code to represent ambiguous encoding results.

5 - Using Multi Input Deep Neural Network for Predicting Glucose Level in Diabetes Patients

Chi Wen Chang, UTSA, San Antonio, TX, United States, Adel Alaeddini

Type 2 diabetes (T2DM) is a major health problem that places a heavy burden on patients and the health care system. Using the correlation between diabetes and blood glucose levels, glucose levels and certain metabolic factors of the patients can be used to predict the level of diabetes. In this study, we research the temporal neural network (TCN) to predict the trajectory of glucose levels in multiple patients. Using real-world data sets, we demonstrate the effectiveness of neural networks in providing preventive measures for physicians and patients to reduce potential risks in diagnosis.

■ SD30

CC- Room 6A

Tutorial: Deep Learning in Computer Vision: Methods, Interpretation, Causation and Fairness

Emerging Topic: Tutorials

Emerging Topic Session

1 - Tutorial – Deep Learning in Computer Vision: Methods, Interpretation, Causation and Fairness

Param Vir Singh, Carnegie Mellon University, Pittsburgh, PA, 15215-1437, United States, Nikhil Malik

Deep learning models have succeeded at a variety of human intelligence tasks and are already being used at commercial scale. These models largely rely on the standard gradient descent optimization of parameters W, which maps an input X to an output y =f(X;W). The optimization procedure minimizes the loss (difference) between the model output y and actual output y. As an example, in the cancer detection setting, X is an MRI image, while y is the presence or absence of cancer. Three key ingredients hint at the reason behind deep learning's power. (1) Deep architectures that can better adapt to breaking down complex functions into a composition of simpler abstract parts. (2) Standard gradient descent methods that can attain local minima on a nonconvex Loss(y,y) function that are close enough to the global minima. (3) Learning algorithms that can be executed on parallel computing hardware (e.g., GPUs), thus making the optimization viable over hundreds of millions of observations (X,y). Computer vision tasks, where the input X is a high-dimensional image or video, are particularly suited to deep learning application. Recent advances in deep architectures, i.e., inception modules, attention networks, adversarial networks and DeepRL, have opened up completely new applications that were previously unexplored. However, the breakneck progress to replace human tasks with deep learning comes with caveats. These deep models tend to evade interpretation, lack causal relationships between input X and output y and may inadvertently mimic not just human actions but human biases and stereotypes. In this tutorial, we provide an intuitive explanation of deep learning methods in computer vision as well as limitations in practice.

■ SD31

CC- Room 6B

System Deterrence and Resiliency

Sponsored: Military and Security

Sponsored Session

Chair: Paul L Goethals, United States Military Academy, West Point, NY, 10996, United States

1 - Analyzing System Deterrence Through Attacker-Defender Games under Uncertainty

Sam Chatterjee, Pacific Northwest National Laboratory, Richland, WA, United States, Casey J. Perkins, Nick Betzsold, Robert T. Brigantic

Analyzing effects of defender actions on adaptive adversary behavior in a system security context is a challenging research problem. A defender with limited resources must adopt deterrent strategies to gain advantage against a resourceful adversary. This talk will outline multiple attacker-defender games under uncertainty to reason about deterrence. First, mathematical modeling elements of incomplete information games will be discussed. Then, a deep dive based on varying player perceptions and beliefs will be presented, including equilibrium solution concepts for signaling games and Hypergames.

2 - Operationalizing System Deterrence Through Signaling Games

Nick Betzsold, Data Scientist, Pacific Northwest National Laboratory, Richland, WA, United States, nicholas.betzsold@pnnl.gov

In this talk, we demonstrate an R Shiny app that implements attacker-defender signaling games for optimizing deterrence strategies. Signaling games provide a mathematical framework to reason about deterrence and model varying player beliefs/uncertainties. A key advancement in this research has been the development of an interactive tool that visually evaluates deterrence strategies, identifying favorable outcomes at equilibria. First, we discuss properties of deterrence and signaling games. Next, we present perfect Bayesian equilibria solution strategies. Finally, we showcase the Shiny app's power to assist an analyst and facilitate efficient systems-level deterrence analysis.

3 - Key Features of Effective CSIRT Processes

Prashanth Rajivan, PhD, University of Washington, Seattle, WA, United States, Norbou Buchler, Cleotilde Gonzalez

To counter the growing number of cyber attacks, organizations need high-performing security operation teams. At this point, it is unclear how cyber defense teams are organized in working together to mount and conduct an effective cyber defense. We collected data from Mid-Atlantic Collegiate Cyber Defense Competition using wearable social sensors to assess face-to-face interactions and using a teamwork instrument called OAT (Observational Assessment of Teamwork) to assess teamwork and leadership behaviors in cyber defense. Our results reveal key features of effective team processes defined by outcome measures of scored team success.

4 - A Hybrid Recovery Framework for Resilient Interconnected Network Systems

Nita Yodo, North Dakota State University, Fargo, ND, United States, Paul L. Goethals

To realize system resiliency following a disruption event, there are many recovery approaches that are deemed to be effective in recovering networked systems. The interconnected relationship between networks complicates the recovery process. A meticulously planned recovery approach that works well for a specific network, may lose its effectiveness when applied to interconnected networks. This research proposes a hybrid recovery framework where a set of effective recovery approaches will be fused together to obtain an integrated recovery plan that ensures a target resilience level is achieved.

■ SD32

CC- Room 6C

Undergraduate Operations Research Prize II

Emerging Topic: Undergraduate Operations Research Prize

Emerging Topic Session

Chair: Nan Kong, Purdue University, Biomedical Engineering, West Lafayette, IN, 47906-2032, United States

Co-Chair: Lincoln J. Chandler, Chandler Decision Services, Chicago, IL, 60623, United States

1 - Award Presenter

Liangyuan Na, Massachusetts Institue of Technology, 77 Massachusetts Avenue, Bldg. E40-103, Cambridge, MA, 02139, United States

2 - Award Presenter

Otto Hendrik, Karlsruhe Institute of Technology, Karlsruhe, Germany

3 - Award Presenter

Milan Preet Kaur, University of Waterloo, Waterloo, ON, Canada

■ SD33

CC- Room 602

Conic Optimization in Julia and JuMP

Sponsored: Optimization/Computational Optimization and Software

Sponsored Session

Chair: Juan Pablo Vielma, Massachusetts Institute of Technology, Cambridge, MA, 02139, United States

1 - Complex Semidefinite and Sum-of-squares Optimization with Hypatia.jl

Christopher D. Coey, MIT, Cambridge, MA, 02138, United States, Juan Pablo Vielma, Lea Kapelevich

Motivated by applications in optimal power flow (OPF), we present sum-of-squares-based formulations for polynomial optimization problems over multivariate complex space. Using our new conic interior-point solver Hypatia, which can handle nonsymmetric cones, we solve large complex-SOS problems and perform performance comparisons.

2 - The Hypatia.jl Solver: Conic Interior Point Algorithms and Interfaces

Lea Kapelevich, Massachusetts Institute of Technology, Cambridge, MA, United States, Christopher D. Coey, Juan Pablo Vielma

We present Hypatia.jl, an open-source and highly-configurable conic interior point solver written in Julia. Hypatia is accessible through a native interface or though MathOptInterface (and hence JuMP). We demonstrate the generality of Hypatia's novel primal-dual algorithms for nonsymmetric cone optimization and discuss algorithmic features such as direct or indirect methods for linear systems, dynamical adjustment of numerical precision, and alternative central path proximity measures.

3 - Cutting Planes for Mixed-integer Conic Optimization

Mathieu Tanneau, Polytechnique Montréal, Montreal, QC, Canada, mathieu.tanneau@polymtl.ca, Andrea Lodi, Juan Pablo Vielma

We investigate the separation of disjunctive cuts for mixed-integer conic problems. Leveraging conic duality, we formulate a cut-generating conic program (CGCP) to separate violated disjunctive cuts. In particular, we study how the choice of normalization in CGCP impacts duality failures, thereby exposing challenges that are specific to non-linear settings. Then, we investigate how disjunctive cuts can be strengthened. We propose a geometric which, in a linear setting, reduces to classical monoidal strengthening. Finally, we report preliminary results on the strength of lift-and-project cuts on instances from the CBLIB library.

4 - Proxsdp.jl : Exploiting Low-rank Structure in Semidefinite Programming by Approximate Operator Splitting

Mario Souto, PUC-Rio University, Rio de Janeiro, Brazil, mariohsouto@gmail.com, Joaquim D. Garcia, Álvaro Veiga

ProxSDP is an open source semidefinite programming (SDP) solver developed in Julia language. ProxSDP solves general SDP problems by means of a first order proximal algorithm based on the primal-dual hybrid gradient (PDHG). The main advantage of ProxSDP over other state-of-the-art solvers is the ability of exploit the low-rank property inherent to several SDP problems. This feature allows the PDHG method to efficiently scale to larger instances.

■ SD34

CC- Room 603

Global Optimization Algorithms – Theory and Application

Sponsored: Optimization/Global Optimization

Sponsored Session

Chair: Yajun Lu, Oklahoma State University, Stillwater, OK, 74078, United States

Chair: Mostafa Amini, Oklahoma State University, Stillwater, OK, 74075, United States

1 - Separation Procedures for Pickup and Delivery Problem with Loading Constraints

Devaraj Radha Krishnan, Oklahoma State University, Stillwater, OK, United States, devaaero10z@gmail.com

In Pickup and Delivery problem (PDP), if multiple shipments are consolidated and placed in a vehicle, then Last-In-First-Out (LIFO) order for pickup and delivery becomes a desirable constraint. In this work, we relax the LIFO constraints and present exact formulations and a branch-and-cut algorithm for PDP with LIFO violation penalties. This is motivated by finding effective trade-off between travel distance and LIFO loading violation. Furthermore, we explore nested integral and fractional separation procedures within our branch-and-cut framework.

2 - Artificial Intelligence, Advanced Learners have Led to Development of New Classes of Systems

Giulia Pedrielli, Arizona State University, Tempe, AZ, United States, Giulia.Pedrielli@asu.edu

Artificial Intelligence, Advanced Learners have led to the development of new classes of Systems posing new challenges for optimal design and control. In this talk, we refer at large to Stochastic Optimization methods, where the focus is on families of algorithms that deliberately inject randomness in the search process. In this context, we try to develop methods to be applied in cases where, (1) there is no homogeneous dynamics of the systems, (2) high effective dimensions need to be considered, and (3) we can construct clever approximations of the system behavior to facilitate the process.

3 - Application of Black-box Global Optimization Techniques for Automatic Test Generation for the Falsification of Highly Complex Cyber-physical Systems

Logan Mathesen, Graduate Research Assistant, Arizona State University, Tempe, AZ, United States, lmathese@asu.edu, Giulia Pedrielli

We focus on developing global optimization techniques for requirements driven search-based test case generation for quickly finding falsifications, unsafe or undesirable behaviors, of Cyber-Physical Systems (CPS). We implement an instance of the Stochastic Optimization with Adaptive Restart (SOAR) black-box optimization framework, that adaptively alternates between an exploitative local search approach and an exploratory global search. This instance of SOAR is applied to the control protocol algorithm for a highly complex real-world Cyber-Physical System. We give insights to global optimization approaches to the falsification problem and give intuition on learned best practices.

4 - Pareto Center Based Parallel Surrogate Optimization Algorithm for Computationally Expensive Nonconvex Mixed-integer Black-box Optimization Problems

Limeng Liu, National University of Singapore, Singapore, Singapore, limeng_liu@u.nus.edu, Christine Shoemaker

This work introduces a parallel surrogate-based optimization method for computationally expensive nonlinear mixed-integer black-box Optimization Problems. The proposed algorithm, SOP-MI combines efficient parallel framework with multiple mixed-integer sampling method, which can solve nonlinear, non-convex mixed-integer problems efficiently. The parallel framework integrated ideas from multi-objective optimization and tabu search. Almost sure convergence is proved for proposed algorithm. In numerical experiments, results show that SOP-MI is significantly better than other compared algorithms especially when the objective function is multi-modal and with many local minimum.

5 - A Convex Optimization Framework for Robustness Analysis of Neural Networks

Mahyar Fazlyab, Postdoctoral Researcher, University of Pennsylvania, Philadelphia, PA, United States

Analyzing the robustness of neural networks against input uncertainties and adversarial attacks has many applications ranging from safety verification and sensitivity analysis to robust training. In this talk, we propose a semidefinite programming (SDP) framework for safety verification and robustness analysis of neural networks with general activation functions. Our main idea is to abstract various properties of activation functions (e.g., monotonicity, bounded slope, bounded values, and repetition across layers) with the formalism of quadratic constraints. We then show how we can analyze various properties of the abstracted network via semidefinite programming (SDP).

6 - 2d Tomography Using a Trans-dimensional Approach

Reetam Biswas, The University of Texas at Austin, Austin, TX, United States, reetam@utexas.edu, Mrinal Kanti Sen, Adrien Arnulf

Full Waveform Inversion (FWI) has become a powerful tool to generate high-resolution subsurface velocity model. FWI attempts to solve a non-linear and non-unique inverse problem and is traditionally based on a local optimization technique and thus quickly get stuck in local minima. To avoid this, FWI requires a good starting model, which in some cases need to be close enough to the true model. Here, we estimate a good starting model solving a first-arrival traveltime tomography of seismic data. We solve using a trans-dimensional approach, based on a Bayesian framework. The number of model parameters is treated as a variable. We use reversible jump MCMC to sample models, and estimate uncertainty.

■ SD35

CC- Room 604

Combinatorial Optimization

Contributed Session

Chair: Fernando Antonio Medrano, Texas A&M University-Corpus Christi, Corpus Christi, TX, 78412, United States

1 - Online Total Bipartite Matching Problem

Meghan Shanks, University of Illinois at Urbana-Champaign, Urbana, IL, United States, meghans2@illinois.edu, Sheldon H. Jacobson

This paper analyzes a variant of Online Bipartite Matching in which incoming vertices must be matched to some job, even if there are no available edges. A reward is only gained for matchings that are made across some edge. This paper describes lower bounds for the most general version of this problem. It then provides an optimal policy for this problem when the underlying bipartite graph meets certain conditions and identifies the most general conditions under which this policy is guaranteed to be optimal.

2 - Improving Nash Social Welfare Approximations

Peter McGlaughlin, University of Illinois Urbana Champaign, Urbana, IL, United States, mcglghl2@illinois.edu

We consider the fair allocation of indivisible goods among N agents using Nash social welfare (NSW) as our main fairness criterion. It is known that a max NSW allocation also meets multiple other fairness metrics and achieves Pareto optimality. However, existing approximations fail to satisfy all of the remarkable fairness guarantees offered by a max NSW allocation, instead targeting only the specific NSW objective. We address this issue by presenting a 2 max NSW, Prop-1, 1/(2N) MMS, and Pareto optimal allocation in strongly polynomial time.

3 - An Approximation Algorithm of Connected Maximum Coverage Problem for Detecting Mutated Pathways in Cancer

Xu Rao, University of California-Berkeley, Berkeley, CA, United States, Dorit Simona Hochbaum

The maximum k-coverage problem is to select, among subsets of a universal set, k sets the union of which maximizes the number of elements covered. The connected k-coverage problem has an underlying graph where each node is associated with a subset, and the goal is to select a connected subgraph on k nodes that maximizes the number of covered elements. This problem is inspired by mutated pathways detection, where a node represents a gene mutation associated with a set of patients with the mutation, and edges represent gene interactions. We introduce an efficient approximation algorithm for the problem, which improves on the state-of-the-art. This algorithm also applies to monotone submodular function.

4 - Submodular Maximization via Contention Resolution Schemes: A New Polyhedral Viewpoint

Simon Bruggmann, ETH Zurich, Zurich, Switzerland, Rico Zenklusen

Constrained submodular maximization enjoys a wide range of applications from machine learning to sensor placement. A standard way to approach such problem is via relaxation and rounding. Whereas almost problem-independent ways are known to approximately solve strong relaxations, the design of good rounding procedures is highly non-trivial. So-called contention resolution schemes became the most versatile rounding tool in this context. We present a novel, polyhedral viewpoint on how to construct and analyze them, and leverage it to design the currently best contention resolution schemes for matching constraints.

5 - A Model for the Dynamic Stable Set Problem

Christopher Muir, University of Tennessee-Knoxville, Knoxville, TN, 37922, United States, Alejandro Toriello

This work studies a dynamic model of the stable set problem. In this model, the topology of the graph is known probabilistically and information is revealed as vertices are added to the set. We show complexity results suggesting that even for restricted graph classes the problem is intractable. For the general case, we present polyhedral results and develop valid inequalities for the problem. Finally, we demonstrate the computational performance of the inequalities alongside various heuristic methods.

6 - The Complete Vertex P-center Problem: An Exact Set Covering Method with Brute Force Combinatorics

F. Antonio Medrano, Assistant Professor, Texas A&M University, Corpus Christi, Corpus Christi, TX, United States, antonio.medrano@tamucc.edu

The vertex p-Center problem (PCP) consists of locating p facilities that cover all n demands in order to minimize the maximum distance between a demand and the facility that covers it. The complete p-Center problem (CPCP) extends the formulation to solve the for all p-values from 1 to N, where N is the number of nodes to cover. This provides a complete coverage trade-off curve between number of facilities and coverage radius. We propose solving the CPCP using an iterative location set covering approach with selecting only radius values that have the potential to be exact solutions. Experiments find that this set covering method is very fast, especially when combined with brute force combinatorics.

■ SD36

CC- Room 605

Optimization and Robust Estimation

Sponsored: Optimization/Optimization Under Uncertainty

Sponsored Session

Chair: Henry Lam, Columbia University, NY, United States

1 - A Semidefinite Programming Based Kernel Clustering Algorithm for Gaussian Mixture Models with Outliers

Prateek Raj Srivastava, The University of Texas at Austin, Engineering Training Center II (ETC), Austin, TX, 78712, United States, prateekrs@utexas.edu, Purnamrita Sarkar, Grani A. Hanasusanto

We consider the problem of clustering data points generated from a mixture of Gaussians in the presence of outliers. We propose a semidefinite programming based algorithm that takes the original data as input in the form of a Gaussian kernel matrix, uses the SDP formulation to denoise the data and applies spectral clustering to recover the cluster labels. We obtain theoretical guarantees on the error rate for our algorithm and show that the rate obtained is small provided there is reasonable separation between cluster centers. We compare the performance of our algorithm with existing algorithms like k-means, spectral clustering and other SDP-based formulations on simulated and real world datasets.

2 - Optimistic Likelihood Problems using Geodesically Convex Optimization

Man-Chung Yue, Imperial College London, 1st Floor, 1 Cobbold Road, Shepherds Bush, London, W12 9LA, United Kingdom, Viet Anh Nguyen, Soroosh Shafieezadeh Abadeh, Daniel Kuhn, Wolfram Wiesemann

When evaluating the likelihood of an observation, the nominal distribution for the observation is estimated from data, which makes it susceptible to estimation errors. To alleviate this issue, we propose to replace the nominal distribution with an ambiguity set containing all distributions sufficiently close to the nominal distribution. When this proximity is measured by the Fisher-Rao distance or the KL-divergence, the emerging optimistic likelihood can be calculated efficiently using geodesically or standard convex optimization. We showcase the advantages of our optimistic likelihoods on a classification problem using artificially generated as well as standard benchmark instances.

3 - Exploiting Partial Correlations in Distributionally Robust Optimization

Karthik Natarajan, Singapore University of Technology and Design, Singapore, 439959, Singapore

We identify partial correlation information structures that allow for simpler reformulations in evaluating the maximum expected value of mixed integer linear programs with random objective coefficients. In some cases, this lends itself to efficient representations that result in polynomial-time solvable instances, most notably for the distributionally robust appointment scheduling problem with random job durations as well as for computing tight bounds in PERT networks and linear assignment problems.

4 - Distributional Representation and Optimization under Coordinate-wise Monotonicity

Henry Lam, Columbia University, New York, NY, 10027, United States, henry.lam@columbia.edu

We consider the estimation of performance measures using distributionally robust optimization under coordinate-wise monotonicity of a multivariate density. We explain how this shape information is more robust than other similar candidates in the context of statistical extreme event analysis. We show a mixture representation for such class of densities using a new notion of rectangle embedding sets, and demonstrate how it facilitates the imposition of tractable optimization formulation.

■ SD37

CC- Room 606

Learning and Optimization for Decision Making

Sponsored: Optimization/Optimization Under Uncertainty

Sponsored Session

Chair: Daniel Bienstock, Columbia University, NY, United States

Co-Chair: Apurv Shukla, Columbia University, New York City, NY, United States

1 - Price Coordination and Demand Learning in Platform Economies

Hongfan Chen, University of Chicago, Chicago, IL, 60615, United States, John R. Birge

This talk addresses the following questions: (i) Should a platform share its proprietary market information to decentralized sellers under demand model uncertainty? (ii) How should a platform design the price coordination mechanism under model uncertainty? We present results that provide answers to each question in a platform setting.

2 - Approximations for Markovian Contextual Bandit Problems

David Brown, Duke University, Fuqua School of Business, Durham, NC, 27708, United States, dbbrown@duke.edu

We study a class of contextual bandit problems; the model allows for both restless arms and stochastic budget constraints. We compare performance bounds based on approximate linear programming and Lagrangian relaxations, and develop a feasible policy based on these approximations. We show that the resulting policy is asymptotically optimal as the number of arms grows. We demonstrate the methods on an application involving a consumer learning about a new set of products through experience.

3 - Non Stationary Streaming PCA

Apurv Shukla, Columbia University, New York, NY, 10025, United States, apurv.shukla@columbia.edu

We consider the problem of streaming principal component analysis (PCA) when the observations are noisy and generated in a non-stationary environment. Given T, p-dimensional noisy observations sampled from a non-stationary variant of the spiked covariance model, our goal is to construct the best linear k-dimensional subspace of the terminal observations. We study the effect of non-stationarity by establishing a lower bound on the performance any algorithm. We establish the convergence behaviour of the noisy power method using a novel proof technique which maybe of independent interest. We conclude that the recovery guarantee of the noisy power method matches the fundamental limit.

4 - Learning Sparse Linear Models with Integer Coefficients

Cynthia Rudin, Duke, LSRC / Box 90129, Durham, NC, 27708, United States

I will present results on learning scoring systems, which are sparse linear models with integer coefficients. This is joint work with Berk Ustun and several medical collaborators.

■ SD38

CC- Room 607

Intersection Between Statistics and Optimization

Sponsored: Optimization/Optimization Under Uncertainty

Sponsored Session

Chair: Hongcheng Liu, University of Florida, Gainesville, FL, 32606, United States

1 - Stochastic Adaptive Cubic Regularization with Negative Curvature for Nonconvex Optimization

Seonho Park, University of Florida, Gainesville, FL, 32603, United States, seonhopark@ufl.edu, Panayote (Panos) M. Pardalos

In this work, we suggest an algorithm to extend the adaptive cubic regularized Newton method to exploiting negative curvature to update even at an unsuccessful iteration for minimizing nonconvex finite-sum functions. We call this method Stochastic Adaptive cubic regularization with Negative Curvature (SANC). We analyze the convergence guarantee to the second order stationary point. Finally, we provide experimental results including neural networks problems supporting the efficiency of our method.

2 - Global Error Bounds and Linear Convergence for Gradient-based Algorithms for Trend Filtering and Convex Clustering

Tianyi Lin, University of California-Berkeley, Berkeley, CA, 94706, United States, darren_lin@berkeley.edu, Nhat Ho, Michael Jordan

We propose a class of first-order gradient-type algorithms to solve structured filtering-clustering problems, include trend filtering and ℓ_1-convex clustering. Our first main result establishes the linear convergence of deterministic gradient-type algorithms despite the extreme ill-conditioning of the difference operator matrices in these problems. This result is based on a convex-concave saddle point formulation of filtering-clustering problems and the fact that the dual form of the problem admits a global error bound. Empirical results show that the proposed algorithms perform comparable to state-of-the-art algorithms, while presenting advantages for scalability.

3 - A Globally Convergent Algorithm for Tensor PCA

Bo Shen, Virginia Tech, Blacksburg, VA, 24061, United States, Weijun Xie, Zhenyu Kong

As one of important machine learning problems, Tensor PCA has been widely applied in signal processing, manufacturing processes, healthcare, etc. Existing approaches might be effective but often are not convergent. This research fills this gap by developing a globally convergent algorithm for Tensor PCA. Our numerical studies demonstrate that the proposed algorithm can be even more effective than the existing ones.

4 - An FPRAS for Strongly NP-hard Folded Concave Penalized High-Dimensional Generalized Linear Models

Charles David Hernandez, University of Florida, Gainesville, FL, 32603, United States

Please check the mobile app for this abstract.

5 - Nonparametric Stochastic Quasi-gradient Method in Stochastic Programming

Shuotao Diao, University of Southern California, Los Angeles, CA, 90007, United States, sdiao@usc.edu, Suvrajeet Sen

This paper studies a fusion of concepts of stochastic approximation and nonparametric statistical learning methods for predictive stochastic programming, which exploits the power of the predictor-response relationship. Nonparametric stochastic quasi-gradient method (Nonparametric SQG) which is general enough to include kNN estimation (SQG-kNN) as well as kernel estimation (SQG-Kernel) has been built to solve the problems in predictive stochastic programming. Under certain assumptions, the asymptotic convergence of Nonparametric SQG is guaranteed. The computational performance of both SQG-kNN and SQG-Kernel is demonstrated.

■ SD39

CC- Room 608

Joint Session RAS/Practice Curated: E-commerce and Intermodal Transportation

Sponsored: Railway Applications

Sponsored Session

Chair: Qing He, University at Buffalo, SUNY, Buffalo, NY, 14260, United States

Co-Chair: Steven Jay Tyber, General Electric, Chicago, IL, 60613, United States

Co-Chair: Justin Goodson, Saint Louis University, St. Louis, MO, 63108, United States

1 - Quantifying the Effect of Different Intermodal Terminal Facility Layouts via Simulation

Tyler Dick, U. of Illinois at Urbana-Champaign, Urbana, IL, 61801, United States

To provide industry practitioners with a better understanding of intermodal terminal capacity, this research investigates relationships between various capacity factors and intermodal terminal characteristics via simulation. A simulation model of a domestic intermodal terminal was developed using AnyLogic® software and used to test different facility layouts and operating scenarios.

2 - Testing Intermodal Terminal Optimization Models with Simulation

Patricia Randall, Princeton Consultants, Greenville, SC, 29605, United States, PRandall@princeton.com

Testing optimization models for Intermodal terminal operations requires a realistic, dynamic environment—but doing so in an actual terminal would disrupt operations. Simulation is a viable, robust testing platform for operational software with complex dependencies or for software that would be too costly or risky to test in the field. Simulation's capability to easily model the interaction between entities and incorporate various sources of uncertainty makes it a powerful testing tool for operational software. Highlighting a recent example, we will discuss the basics of simulation software, benefits for using it to test optimization solutions, and tips to get started.

3 - Air-high Speed Rail Intermodal Transport Network Design Problem of China

Dandan Li, Southwest Jiaotong University, Chengdu, 610031, China, 2016210837@my.swjtu.edu.cn, Mi Gan, Mingfei Wang

The rapid growth of e-commerce and the existed idle capacity of high-speed railway in China result in a novel intermodal transport pattern for express delivery, which is air-high speed rail transport(AHSR). In this research, the design of the AHSR network of China is studied. First, we analyze the status quo and feasibility of AHSR. Then, the potential hub city of AHSR network is determined by express demand forecasting and hub city centrality evaluation. Thirdly, the network design model is constructed through macro-planning and micro-operations views, respectively. The models and algorithms are verified by a real case of mainland China.

4 - System-wide Delay Optimizer for Train Schedules at Intermodal Facilities

Di Hoai Nguyen, BNSF, Ft. Worth, TX, United States, Amirali Ghahari

We study a train scheduling problem subject to capacity constraints at major intermodal facilities in a network. Each train carries some number of intermodal shipments (containers/trailers) from their origin facility to their destination facility. At each facility, the train requires processing on the lead tracks and strip tracks, both of which are capacitated. Given a system-wide train schedule which includes planned arrival/departure times for all trains, we formulate an Integer-Program which aims to minimize the system-wide cost of delays, while adhering to each hub's capacity limitations.

■ SD40

CC- Room 609

Optimization in Machine Learning

Sponsored: Optimization/Nonlinear Programming

Sponsored Session

Chair: Jonathan Eckstein, Rutgers University, Piscataway, NJ, 02139, United States

1 - Robust Accelerated Gradient Methods

Mert Gurbuzbalaban, Rutgers University, Piscataway, NJ, 02139, United States

We study the trade-offs between convergence rate and robustness to gradient errors in designing a first-order algorithm. We focus on gradient descent and accelerated gradient methods for minimizing strongly convex functions when the gradient has random errors in the form of additive white noise. We define the robustness of an algorithm to noise as the asymptotic expected suboptimality of the iterate sequence to input noise power. We develop a framework that selects parameters of each algorithm to achieve a particular trade-off between rate and robustness. Our framework leads to several algorithms that can perform better than other state-of-the-art methods in the presence of random gradient noise.

2 - Forward-step Projective Splitting Methods for Convex Optimization and Monotone Inclusions

Patrick R. Johnstone, Postdoctoral Associate, Rutgers University, Piscataway, NJ, 08873, United States, patrick.r.johnstone@gmail.com, Jonathan Eckstein

We develop several new variants of the projective splitting method which can use forward steps rather than only resolvents. These results establish symmetries between projective splitting algorithms, the forward-backward splitting method (FB), and the forward-backward-forward method (FBF). Like in FBF, Lipschitz monotone operators require two forward steps within our projective splitting framework. Like in FB, cocoercive operators require one forward step. The stepsize constraints also coincide with the classical methods. Backtracking linesearch variants are also derived. With this progress, projective splitting has become a modern and powerful operator splitting framework.

3 - Rule-enhanced Classification and Regression Models

Ai Kagawa, Brookhaven National Laboratory, Upton, NY, 08854, United States, Jonathan Eckstein, Noam Goldberg

LPBR (LPBoost) and REPR (Rule-Enhanced Penalized Regression) are boosting as well as column generation (CG) methods for classification and regression problems, respectively. Both methods dynamically generate rules in each CG iteration. The combination of the generated rules with margin maximization and regularization can respectively produce robust classification and regression models. Their CG subproblems are the NP-hard RMA (Rectangular Maximum Agreement) problem, solved either heuristically or by exact parallel branch and bound.

4 - A Branch-and-bound Algorithm for Rectangular Maximum Agreement

Jonathan Eckstein, Rutgers University, Piscataway, NJ, 08854, United States, Ai Kagawa

We describe a branch-and-bound procedure for solving an NP-hard problem that arises as a subproblem in several machine learning contexts. Given observations in n-space with signed weights, the problem is to find an axis-parallel "box" set such that the sum of the weights of the observations it contains has maximum absolute value. We first describe a MIP formulation for this problem, which turns out to be difficult to solve. Next we describe an alternative, combinatorial branch-and-bound procedure and the various data structures and implementation techniques needed to make it practical. The algorithm has been implemented using PEBBL.

■ SD41

CC- Room 610

Conic Optimization I

Sponsored: Optimization/Linear and Conic Optimization

Sponsored Session

Chair: Somayeh Moazeni, Stevens Institute of Technology, Hoboken, NJ, 07030, United States

1 - Parametric Analysis of Semidefinite Optimization

Tamas Terlaky, Lehigh University, Bethlehem, PA, United States, Ali Mohammad Nezhad

We study parametric analysis of SDO problems w.r.t. the perturbation of the objective function. We study the behavior of the optimal partition and optimal set mapping in a so-called nonlinearity interval, and investigate the sensitivity of the approximation of the optimal partition in a nonlinearity interval. The approximation of the optimal partition is obtained from a bounded sequence of interior solutions on, or in a neighborhood of the central path. An upper bound on the distance between the approximations of the optimal partitions of the original and perturbed problems is presented.

2 - Low Order Complexity SDP/SOS Methods for Polynomial Optimization

Motakuri V. Ramana, Research Scientist and Consultant, Warangal, India

Polynomial optimization problems, i.e. optimization, feasibility and related problems involving polynomial functions where we seek globally optimal solutions or exact certifications, are very central and useful, as well as very hard class of NP-Hard problems. A class of Semidefinite Programming (or equivalently Sums of Squares) methods of single-exponential complexity for feasibility as well as general polynomial optimization problems will be presented, that are, to the contributor's knowledge, first known of that complexity order.

3 - Scaled Diagonally Dominant Tensors in Polynomial Optimization

Xin Shi, Lehigh University, Bethlehem, PA, United States, xis316@lehigh.edu, Luis F. Zuluaga

Diagonally dominate (DD) matrices and scaled diagonally dominant (SDD) matrices have been used in characterizing two subclasses of sum of squares polynomials (SOS). In our work, we construct two subclasses of positive semidefinite polynomials (PSD) which are based on DD tensors and SDD tensors. With the new subclasses, SOS programs and PSD programs may be relaxed to alternative LP programs and SOCP programs than the ones obtained from DD and SDD matrices. We characterize different relationships between these relaxations.

4 - Towards Efficient Approximation of P-cones

Yuriy Zinchenko, University of Calgary, University of Calgary, MS446, 2500 University Drive Nw, Calgary, AB, T2N 1N4, Canada

The second-order cone (SOC) has gained wide applicability in optimization. SOC may be effectively handled by interior-point methods and is well approximated with polyhedra. Ben-Tal and Nemirovski constructed an elegant 'optimal' approximation scheme where the number of linear inequalities grows logarithmically with approximation precision. In contrast, the situation with SOC extensions to p- cones remained dramatically different. Neither there are dimension-invariant SC-barriers for such cones, nor has one been able to approximate these cones efficiently. We describe a novel approximation approach and provide evidence that an efficient polyhedral approximation is within reach.

■ SD42

CC- Room 611

ARPA-E Grid Optimization Competition

Sponsored: Optimization/Network Optimization

Sponsored Session

Chair: Kory Hedman

1 - ARPA-E Grid Optimization Competition: Challenge 1 Overview

Kory W. Hedman, Program Director, ARPA-E, US DOE, Washington, DC, United States, Kory.Hedman@hq.doe.gov

This discussion will focus on Challenge 1 of ARPA-E's Grid Optimization (GO) Competition. The GO Competition has been a year-long algorithm competition to solve security-constrained optimal power flow (SCOPF), a nonconvex network optimization problem that must be solved in real-time operations by utilities and ISOs. APRA-E has challenged competitors to build and execute new SCOPF algorithms that provide minimum cost operating solutions while maintaining grid reliability. This talk will provide an overview of the first year of the competition, including challenges and lessons learned.

2 - ARPA-E Grid Optimization Competition: Challenge 1 Top Performers

Ashley Arigoni, Lead Scientist, ARPA-E/QS-2, Denver, CO, United States, ashley.arigoni@qs-2.com

ARPA-E will invite top performing teams in Challenge 1 of the Grid Optimization (GO) Competition to present their successful algorithms and strategies. This talk will highlight innovative and transformative methodologies which are expected to improve upon grid software presently used in real-time operations. The top performers in Challenge 1 will showcase approaches that will be representative of the software evolution required by industry to feasibly accommodate and optimally dispatch a modern electric grid consisting heavily of distributed and intermittent resources.

3 - ARPA-E Grid Optimization Competition: Challenge 1 Results

Jesse T. Holzer, Pacific Northwest National Laboratory, Richland, WA, United States, jesse.holzer@pnnl.gov, Stephen T. Elbert

We have results from the ARPA-E Grid Optimization Competition Challenge 1! Over 20 teams of researchers, from across the U.S. and around the world, brought together expertise in power systems, optimization, and software engineering to develop innovative solution methods for a challenging security constrained AC optimal power flow problem. We've put their algorithms to the test in our HPC environment on a suite hundreds of problem instances over a range of sizes and difficulties. We'll share some highlights and welcome the top solvers to tell us about their approaches.

4 - ARPA-E Grid Optimization Competition: Challenge 1 Methodologies

Carleton Coffrin, Los Alamos National Laboratory, Los Alamos, NM, United States

The security-constrained optimal power flow (SCOPF) problem is a non-convex mixed integer program that plays a critical role in the daily operations of modern power systems. Industrial SCOPF instances are large-scale, featuring thousands to millions of decisions variables, and need to be solved very quickly, on the order of minutes. Together these real-world requirements present a formidable optimization challenge. This presentation provides an overview of the key approaches to exploiting the structure of the SCOPF problem to solve industrial-scale instances and investigates the quality-performance trade offs of different solution methodologies.

■ SD43

CC- Room 612

Recent Advances in Non-Convex Optimization

Sponsored: Computing

Sponsored Session

Chair: Andres Gomez, University of Pittsburgh, Pittsburgh, PA, 15217, United States

1 - Polyhedral Results for Tree Ensembles Optimization

Jongeun Kim, Bijan Taslimi, Mohit Tawarmalani, Piscataway, NJ, 02139, United States, Jean-Philippe P. Richard

Tree ensemble models are often used as regression functions to predict the effect of input variables. Recently, optimization of tree ensembles has been introduced as a tool for making optimal decisions that maximize profit or minimize cost. In this talk, we propose a new mixed-integer programming formulation for this problem that uses a combination of the reformulation-linearization technique and graph-theoretical concepts.

2 - Approximation Algorithms for the Maximum Entropy Sampling Problem

Yongchun Li, Virginia Tech, Blacksburg, VA, United States, liyc@vt.edu, Weijun Xie

This paper studies the maximum entropy sampling problem (MESP), which selects the most informative principal submatrix of a given size from a positive semidefinite matrix. We first derive a new convex integer programming formulation for MESP. Using the convex relaxation solution, we propose a sampling algorithm and its deterministic implementation, which improves the best known approximation bound. We also analyze the commonly used local search algorithm for MESP and prove its first known approximation bound. Finally, we extend our analyses to other selection criteria.

3 - Exact Guarantees on the Absence of Spurious Local Minima for Non-negative Robust Principal Component Analysis

Salar Fattahi, University of California-Berkeley, Berkeley, CA, United States, fattahi@berkeley.edu, Somayeh Sojoudi

This work is concerned with the non-negative robust principal component analysis (PCA), where the goal is to recover the non-negative principal component of a data matrix precisely, where some measurements could be corrupted with sparse noise. Most of the techniques for the robust PCA rely on convex relaxation methods, which significantly increase the number of variables. In contrast, the Burer-Monteiro approach can be used to cast the robust PCA as a non-convex l-1 optimization problem with a significantly smaller number of variables. In this work, we show that this formulation of the positive robust PCA has no spurious local minima and its global minimum coincides with the true component.

4 - Worst-case Iteration Bounds for Log Barrier Methods for Problems with Nonconvex Constraints

Oliver Hinder, Stanford University, Stanford, CA, United States, Yinyu Ye

Interior point methods (IPMs) that handle nonconvex constraints such as IPOPT, KNITRO and LOQO have had enormous practical success. Unfortunately, current analyses of log barrier methods with general constraints implicitly prove guarantees with exponential dependencies on $1/\mu$ where μ is the barrier penalty parameter. We provide an IPM that finds a μ-approximate Fritz John point by solving $\mathcal{O}(\mu^{-7/4})$ trust-region subproblems when the objective and constraints have Lipschitz first and second derivatives.

5 - Naive Feature Selection: Sparsity and Robustness in Naive Bayes

Armin Askari, UC Berkeley, Berkeley, CA, United States, aaskari@berkeley.edu, Laurent El Ghaoui, Alexandre d'Aspremont

Naive Bayes remains an attractive classification method, especially in very large-scale settings. We propose a cardinality-constrained version of naive Bayes, which can be used for feature selection. This leads to a combinatorial maximum-likelihood problem, for which we provide an exact solution in the case of binary data, or a bound in the multinomial case which becomes tight as the sparsity level increases. We then consider the case when the data is not exactly known, and develop robust maximum likelihood (max-min) counterparts. Numerical experiments show that our model is competitive with other feature selection methods, while being orders of magnitude faster to train.

■ SD44

CC- Room 613

New Discrete Optimization Approaches for Machine Learning

Sponsored: Computing

Sponsored Session

Chair: Cong Han Lim, Georgia Institute of Technology, Atlanta, GA, United States

1 - Rank-one Convexification for Sparse Regression

Alper Atamturk, University of California-Berkeley, Industrial Eng. & Operations Research, Berkeley, CA, 94720-1777, United States, Andres Gomez

We derive new strong convex relaxations for sparse regression based on the convex-hull formulations for rank-one quadratic terms with indicator variables. The new relaxations can be be formulated as semidefinite optimization problems. The proposed rank-one strengthening can be interpreted as a non-separable, non-convex sparsity-inducing regularizer, dynamically adjusting its penalty according to the shape of the error function. In our computational experiments with benchmark datasets, the proposed conic formulations are solved within seconds and result in near-optimal solutions with high prediction accuracy and good interpretability for non-convex L0 problems.

2 - An Approximation Algorithm for Training One Node RELU Neural Network

Guanyi Wang, Georgia Institute of Technology, Atlanta, GA, 30332, United States, gwang93@gatech.edu

Training a ReLU regression is a fundamental optimization problem in deep learning. Starting with the NP-hard result of training a ReLU regression, we present an approximation algorithm and analyze the performance of this algorithm under two settings. (1) Given any arbitrary sample points, the approximation algorithm guarantees a n/k approximation ratio. (2) Assume an underlying statistical model, the same algorithm gives an approximation ratio independent of n asymptotically. In practice, the approximation algorithm works better than gradient-descent type (GDT) methods in some cases, and the solution of the approximation algorithm can be used as a starting point of GDT methods.

3 - Conic Subspace Clustering: Paradigm, Algorithms, and Applications

Amin Jalali, Self, Palo Alto, CA, United States, Rebecca Willett

Given samples lying on a few unknown subspaces, subspace clustering amounts to identifying a partition of samples consistent with the corresponding subspace memberships. Many subspace clustering methods first solve a convex optimization problem, based on the so-called self-expressiveness paradigm, to derive a graph embedding, and then feed these affinities into a graph clustering procedure. Conic Subspace Clustering (CSC) is a new paradigm that makes use of the underlying geometry of normalized samples to derive the graph embedding. We will cover important aspects of this new paradigm and how they lead to fast novel algorithms for new regimes of subspace clustering with provable guarantees.

4 - An Efficient Pruning Approach for Robust Isotonic Regression

Cong Han Lim, Georgia Institute of Technology, Atlanta, GA, 30328, United States, clim31@gatech.edu

We study a variant of the classic isotonic regression problem where we use separable robust estimators in the objective function. One can use a simple dynamic program to solve this to within -accuracy (of the global minimum) in O(n/) steps. This approach ignores any inherent properties of the estimators. We combine techniques from the convex case with branch-and-bound ideas, leading to a novel algorithm where the complexity scales with the shape of the functions. This achieves the best known bounds for both the convex (O(nlog(1/)) and the general nonconvex cases. Experiments show that our approach can perform much faster than the DP approach, especially as the desired accuracy increases.

■ SD45

CC- Room 614

Distributed Nonlinear Optimization in Machine Learning

Sponsored: Optimization/Nonlinear Programming

Sponsored Session

Chair: Majid Jahani, Lehigh University, Bethlehem, PA, United States

Chair: Martin Takac, Lehigh Univerity, Bethlehem, PA, United States

1 - Scaling Up Quasi-newton Algorithms: Communication Efficient Distributed SR1

Majid Jahani, Lehigh University, Kehigh University, Bethlehem, PA, United States, maj316@lehigh.edu, Reza Nazari, Albert Solomon Berahas, Sergey Rusakov, Martin Takac

In this paper, we present a scalable distributed implementation of the S-LSR1 algorithm [1]. First, we show that a naive implementation of S-LSR1 requires multiple rounds of expensive communications at every iteration and thus is inefficient. We then propose DS-LSR1, a communication-efficient variant of the S-LSR1 method, that drastically reduces the amount of data communicated at every iteration, that has favorable work-load balancing across nodes and that is matrix-free and inverse-free. Our method scales well in terms of both the dimension of the problem and the number of data points. [1]Berahas, A. S., Jahani, M., & Taká , M. Quasi-Newton Methods for Deep Learning: Forget the Past, Just Sample

2 - The Proximal Primal-dual Algorithm for Fast Distributed Nonconvex Optimization and Learning Over Networks

Davood Hajinezhad, SAS Institute, Cary, NC, 27707, United States, dhajinezhad@gmail.com, Mingyi Hong, Ming-Min Zhao

In this paper we consider nonconvex optimization and learning over a network of distributed nodes. We develop a Proximal Primal-Dual Algorithm (Prox-PDA), which enables the network nodes to distributedly and collectively compute the set of first-order stationary solutions in a global sublinear manner. To the best of our knowledge, this is the first algorithm that enables distributed nonconvex optimization with global sublinear rate guarantees.

3 - Fast Distributed Optimization via Anderson Accelerated Douglas Rachford Splitting

Junzi Zhang, Stanford University, Stanford, CA, United States, Anqi Fu, Stephen P. Boyd

We consider the problem of finite-sum non-smooth convex optimization with general linear constraints, where the objective function summands are only accessible through their proximal operators. To solve it, we propose an Anderson accelerated Douglas-Rachford splitting (A2DR) algorithm, which combines the scalability of Douglas-Rachford splitting and the fast convergence of Anderson acceleration. We show that A2DR either globally converges or provides a certificate of infeasibility/unboundedness under very mild conditions. We describe an open-source implementation (https://github.com/cvxgrp/a2dr) and demonstrate its outstanding performance on a wide range of examples.

4 - Robust Distributed Optimization for Machine Learning: Efficient Algorithms and Challenges

Zachary Charles, Google, Madison, WI, United States, Hongyi Wang, Shashank Rajput, Dimitris Papailiopoulos

In order to scale training of large machine-learning models, we often employ distributed optimization techniques. As these distributed systems grow in size, so too does the probability that a compute node experiences some kind of failure, including hardware failures, software bugs, or the presence of an adversary governing the output of the node. In order to guarantee the reliability of distributed training systems, recent work has proposed training methods that are robust to arbitrary node failures. To improve robustness, recent work generally employs robust aggregation techniques or algorithmic redundancy techniques. While the former suffers from high computation costs, the latter can only tolerate a small number of failures. In this work, we present DETOX, a framework for robust distributed training that combines robust aggregation with algorithmic redundancy. DETOX is designed to be used in tandem with robust aggregation methods, and we show theoretically that this leads to substantial increases in robustness and efficiency. We provide extensive experiments over real distributed setups across a variety of large-scale machine learning tasks, showing that DETOX leads to orders of magnitude accuracy and speedup improvements over many state-of-the-art robust training methods. If time permits, we will discuss some challenges and open problems.

■ SD46

CC- Room 615

Joint Session TSL/ITS/Practice Curated: Data Driven Approaches for Travel Demand and Mobility Analysis

Sponsored: Transportation Science & Logistics/Intelligent Transportation Systems (ITS)

Sponsored Session

1 - Characterizing Data Falsification Effects on Connected Autonomous Vehicle Platoons Using a Forced Vibration Equation

Xiaozheng He, Rensselaer Polytechnic Institute, Troy, NY, United States, hex6@rpi.edu, Pengcheng Wang, Xinkai Wu

The similarity between traffic flow oscillation and mechanical vibration inspires us to model the connected autonomous vehicles (CAVs) dynamics under data falsification attack using a forced vibration equation, where the attack is regarded as an external force to the system. The proposed model facilitates us to derive inherent oscillation properties of the CAV stream and analyze the effects of data falsification attack on CAVs dynamics. Based on the derived properties, we investigate the oscillation severity of CAV streams under the data falsification attack through simulation.

2 - Accounting Latent Information Search in Choice Modeling: A Search Action Model

Yifei Xie, Massachusetts Institute of Technology, Cambridge, MA, United States, yifeix@mit.edu, Mazen Danaf, Angelo Guevara, Arun Akkipenally Prakash, Moshe Ben-Akiva

This paper proposes a choice model that incorporates the information search behavior. Existing models for this purpose often assume that the search process is observed, which is rarely the case in real-world applications. We address this issue by modeling the search decisions as latent. The framework is broadly applicable and of great relevance for travel behavior modeling where real-time travel information is readily available but not always considered in decision-making. The framework is illustrated through Monte Carlo experiments, where model identification and parameter recovery are validated. It is also shown that ignoring unobserved search leads to biased estimates and poor prediction.

3 - Inverse Reinforcement Learning in Improving Driver's Safety

Qiong Hu, Auburn University, Auburn, AL, United States, qzh0011@auburn.edu, Amir Mehdizadeh, Alexander Vinel, Fadel Mounir Megahed

To improve the driver's safety, an MDP model has been developed to find the optimal policy to minimize the risk considering the weather and traffic conditions. The traditional way is to apply data analysis to estimate the relationship between factors and the risk. Our model is to use inverse reinforcement learning to obtain the reward function and help the driver make a better decision during the route such as the time of rest stop or choosing the speed level.

4 - Evaluation of Road Safety Using Machine Learning Methods Incorporating with Visualization Techniques.

Amir Mehdizadeh, Auburn University, Auburn, AL, United States, Azm0127@auburn.edu, Qiong Hu, Alexander Vinel, Fadel Megahed

Traffic, weather and road geometry are the main external factors which impact the crash probability. The interaction between these factors is complex and can potentially increases the crash probability. We first use three unsupervised learning methods (K- means and Hierarchical clustering and Principle Component Analysis) incorporating with different visualization techniques in order to identify different traffic states considering weather condition and road geometry. Then, using crash data, the risk associated with each traffic state is obtained by utilizing different statistical models. Finally, based on the results a set of general rules which impact the road safety is proposed.

5 - Evaluating the Impacts of Real-time Travel Information on Driver Physiology

Shubham Agrawal, Purdue University, West Lafayette, IN, United States, shubham@purdue.edu, Irina Benedyk, Srinivas Peeta

Real-time travel information can help drivers to make informed travel choices, but also distracts them from the primary driving task during information perception and processing. Hence, there is the need for a comprehensive understanding of information impacts on driver cognition. This study analyzes driver's brain electrical activity patterns collected using electroencephalogram (EEG) to assess driver cognition using neurophysiology. Data is collected in a network-level driving simulator environment that simulates realistic route choice decisions under real-time travel information provision.

6 - An Optimization Model for Bike-sharing Inventory Allocation in Competitive Environment

Chenyi Fu, Tianjin University, Tianjin, China, Ning Zhu, Shoufeng Ma

The bike-sharing firm of interests needs to consider whether they can survive the vehement competition with the local monopoly providers when entering into the new areas. This study adopts a multi-stage max-min-max framework to consider the worst-case profit. A myopic method embedded with a constraint-and-column generation approach is presented to obtain an approximate solution. The numerical studies display that when the bikes of the competitor are plentiful, distributing them uniformly can already have great influence on the profit of the firm of interests. Then the algorithm is effective and will generally depend on the number of bikes of two firm and less on the number of OD pairs.

■ SD47

CC- Room 616

Vehicle Routing I

Contributed Session

Chair: Yasel Costa, Fundacion Zaragoza Logistics Center, Wehrgrabengasse 1-3, Steyr, 4400, Australia

1 - GNN-based Path Prediction for Vehicle Routing Problem

Pan Gu, Zhejiang Cainiao Supply Chain Management Co., Hangzhou, China, gupan.gp@cainiao.com, Jian-Ya Ding, Chao Zhang, Lei Shen, Shengyin Li, Bing Wang, Yinghui Xu

Vehicle routing is a classical yet active research area. It is difficult to obtain a satisfactory routing plan by OR model without a deep knowledge on various restrictions. But implicit constraints are difficult to model. In this paper, we propose a deep neural-network method to predict promising paths for the vehicles. We combine supervised GraphSAGE and LSTM as the deep neural networks part, embedding graphs to a low dimensional vector space. The prediction result is integrated in a novel "Vehicle-Trip-Pattern" (VTP) algorithm in Cainiao. Offline experiments show that the prediction model can capture some of the implicit constraints and reduce the number of candidate trips significantly.

2 - Operational Constraints for Real World VRP

Shubhada Kshirsagar, ESRI, Redlands, CA, United States, skshirsagar@esri.com

Solving a standard Vehicle Routing Problem (VRP) to optimality is a difficult challenge. However, the optimal solution is often unrealistic and infeasible in the real world. Additional constraints must be considered to make the solution operationalizable. In this presentation, we examine qualitative constraints like clustering routes; balancing workloads yet being reasonably efficient; sequencing orders on a "Neighborhood" basis; and prioritizing high revenue orders but visiting lower priority ones if possible. We will look at ways these can be defined quantitatively to fit business rules. Though hard to define, these types of constraints are critical for producing an operational solution.

3 - A Novel Process Systems Approach for Vehicle Routing Optimization

Nooshin Nekoiemehr, Optimization Specialist, Hatch Ltd., Mississauga, ON, Canada, nooshin.nekoiemehr@hatch.com, Danielle Zyngier, Hao Li

A novel formulation is proposed to solve vehicle routing problem with pickup and delivery time windows using Process Systems Engineering technology. This framework enables modeling consistency and full integration across value chain systems (production-transportation-distribution). The resulting model can reroute a fleet of vehicles to accommodate new passengers in real-time while still guaranteeing promised delivery times for existing passengers. The efficiency of the method is illustrated through realistic case studies.

4 - Variable Neighborhood Search for the Electric Multi-trip Vehicle Routing Problem with Backhauls, Time Windows and Recharging Stations

Qian Hu, Associate Professor, Nanjing University, Nanjing, China, huqian@nju.edu.cn

Delivery companies now consider electric vehicles in green logistics. We study an electric vehicle routing problem with backhauls, time windows and recharging stations; it also allows heterogeneous electric vehicles and multi-trips. The problem is to find a set of feasible routes to serve all customers and minimize the total cost related to travel distance, waiting and recharging. We propose a hybrid heuristic based on variable neighborhood search with preprocessing, route operators and recharging operations. Computational results show that the heuristic is competent to find good feasible solutions for test instances with up to 1500 customers and 100 recharging stations.

5 - The Hilly Topography Vehicle Routing Problem: A Comprehensive Study for Urban Transportation Planning

Yasel Costa, Fundacion Zaragoza Logistics Center, Zaragoza, Spain, ycosta@zlc.edu.es, Victor Suarez, William Sarache, Tom Van Woensel

The effect of road gradient on fuel consumption has recently attracted much interest. Some scientific contributions have demonstrated that a shortest distance route is not necessary the best solution in terms of green performance (less CO2 emissions). In addition to the above, this paper proposes a new mathematical model for optimizing the fuel consumption equation that considers the topographic profile of transportation routes. Our proposal not only includes a novel formulation for fuel consumption but also address route security issues using the model constraints. Aimed to demonstrate our model validity, we have designed and solved 105 instances of Hilly Topography Vehicle Routing Problem.

■ SD48

CC- Room 617

General Freight Transportation II

Sponsored: Transportation Science & Logistics/Freight Transportation & Logistics

Sponsored Session

Chair: Sandra D. Eksioglu, Clemson University, Clemson, SC, 29634, United States

1 - Coordination Arrangements in Intermodal Transportation: Game Theoretic Analysis

Irina Benedyk, Purdue, West Lafayette, IN, 47906, United States, Srinivas Peeta

This study uses a game theoretic framework that models competitive behaviors of two types of agents (maritime carriers and intermodal terminals), to understand how carriers and terminals can enhance their efficiency through four coordination arrangements (incentives, alliances, change of scope, and collective actions). The analysis of agents' behavioral responses on coordination arrangements is presented. The study findings can be used by the public sector to estimate possible impacts of policies aiming to foster intermodal transportation coordination.

2 - Mitigation Strategies Against Supply Disruption Risk

Ece Sanci, University of Michigan, Ann Arbor, MI, United States Mark Stephen Daskin

The economic impact of disruptions can be enormous when the supply chain design is optimized to perform well under normal circumstances. In this study, we provide a decision support framework based on a multistage stochastic programming model to choose the best mitigation strategy against supply disruption risk. We consider a variety of feasible strategies including improving the reliability of the primary supplier through backup capacity, reserving capacity from a secondary supplier, and increasing inventory levels. Our results show that the payoff of investing in mitigation strategies can be large, in particular, when the adverse effects of the disruption cannot be eliminated for a long time.

3 - Day-to-day Load Planning Strategies in Less-than-truckload Service Networks

Yassine Ridouane, Georgia Institute of Technology, Atlanta, GA, United States, yridouane@gatech.edu, Ian Hodara Herszteg, Natashia Boland, Alan Erera, Martin W.P. Savelsbergh

We propose new strategies for helping dispatchers in their daily decision process for operational load planning in LTL service networks. The freight volume that actually appears during a day of operations does not generally match the daily demand that was forecasted by load planners a week ahead. This renders the service guarantee of shipments hard to meet as the capacity on planned paths may not be enough. We use a time expanded network representation of the problem and present heuristics to solve it in a reasonably acceptable time. We applied these methodologies to realistic instances and the results show a substantial improvement over a set of chosen metrics as compared to a baseline approach.

4 - Exploring K- Best Solutions for the Capacitated Facility Location Problems in the Context of Network Design Decision-making

Claudio B. da Cunha, University of Sao Paulo, Sao Paulo, Brazil, Caue S. Guazzelli

We explore K alternative solutions to a facility location problem that usually arises in Supply Chain Network Design problems. The results on two well-known benchmark instances have shown that for all instances the gaps between the optimal solutions and the 20-best alternative ones were, on average, less than 1%. More surprisingly, 64% of all these alternative solutions had a gap smaller than 0.5%. This suggests that our approach may be used to identify whether near-optimal alternative solutions can yield to a better overall solution from the point of view of the decision-maker that have to consider other aspects, oftentimes qualitative, that cannot be explicitly modeled.

■ SD49

CC- Room 618

Data-driven Modeling and Simulation of Connected and Autonomous Vehicles

Sponsored: Transportation Science & Logistics/Urban Transportation

Sponsored Session

Chair: Kaan Ozbay, New York University, New York, NY, United States

Chair: Joseph Y.J. Chow, New York University, New York, NY, 10012, United States

1 - Application of Learning Classifier Systems in Microscopic Traffic Simulation

Bekir Bartin, Associate Professor, Altinbas University, Istanbul, Turkey

This paper presents the application of XCS learning algorithm in simulating drivers' lane selection behavior in microscopic simulation models of toll plazas. XCS is a machine learning technique that ties reinforcement learning and genetic algorithm. The proposed formulation translates an agent's lane selection decision into a learning problem, assuming that its ultimate objective is to reduce delay and crash risk. The agent is simulated within a hypothetical toll plaza simulation network without any notion of the outcome of its decisions. Through multiple learning episodes and the outcome of its actions i.e., delay and crash risk, it learns the best policy for choosing a toll lane.

2 - An Intersection Control Strategy Based on Transferable Utility for Connected Vehicles

Dianchao Lin, New York University, NYUAD, Saadiyat Island, Abu Dhabi, 129188, United Arab Emirates, dl3404@nyu.edu, Saif Eddin G. Jabari

We present an intersection traffic management scheme that employs transferable utility games. Payoffs to individual vehicles are modeled as travel time savings weighted by value of time. Vehicles at the intersection are divided into two groups based on whether they benefit from applying a system payoff maximizing control scheme every time a new vehicle arrives to the system. The losers are compensated by the winners and the payoff maximizing scheme is applied. We test the effect of increased penetration rates of vehicles involved in the game. We also perform comparisons against other widely used control schemes. Our results demonstrate the viability of the proposed control scheme.

3 - Simulating CAVs on Urban Transportation Networks

Xuegang Ban, University of Washington, Seattle, WA, United States, banx@uw.edu, Yiran Zhang, Qiangqiang Guo

We develop a SUMO simulation model for a urban transportation network. The simulation model is used to simulate mixed traffic flow of CAVs and human driven vehicles, and CAVs with lower level automation.

4 - Connected and Automated Vehicles Impacts Assessment in New York

Camille Kamga, Associate Professor, City College of New York / UTRC, New York, NY, United States, Sandeep Mudigonda, Justin Collombet, Rodrigue Tchamna

The transformative potential of connected and automated (CAV) mobility needs to be assessed considering a wide-range of impacts enhanced safety via collision avoidance, better mobility through signal-vehicle coordination, platooning, etc. and also associated environmental benefits of reduced fuel consumption and greenhouse gas emissions and also significant financial impact. Employing a range of simulation and data sources, these impacts are analyzed for various vehicles and trips in New York. A microscopic, open-source simulation testbed developed in SUMO is being used to assess safety and mobility impacts and benefits to agencies as a part of the NYC CV pilot from CV applications.

5 - Use of Vehicle Trajectory Data-based Calibration of Microscopic Simulation Models for Evaluating Connected Vehicle Technologies

Abdullah Kurkcu, New York University, Brooklyn, NY, United States, ak4728@nyu.edu, Kaan Ozbay

As part of the CV Pilot safety performance evaluation plan, analysis will be conducted using micro-simulation modeling techniques instead of direct field observations. A pure before and after comparison under identical circumstances can be conducted using microscopic traffic simulation tools. Simulation calibration can be viewed as a process of minimizing the difference between simulated and observed traffic measures. Traditionally, only operational measures, such as traffic counts, travel time are used. But to conduct safety oriented analysis, it is essential that safety-related measures, such as safety indicators, to be included in the calibration process.

■ SD50

CC- Room 619

Recent Advances in Facility Design, Layout and Location

Sponsored: Transportation Science & Logistics/Facility Logistics

Sponsored Session

Chair: Rakesh Nagi, U. of Illinois at Urbana-Champaign, Urbana, IL, 61801, United States

1 - Analysis of Workload Inbalance and Mean Response Time of U-shaped Production Line

Yu Zhou, University at Buffalo (SUNY), Buffalo, NY, United States, yzhou67@buffalo.edu, Rajan Batta

A spatial queuing model is applied to analyze a U-shaped production line. Workload imbalance and mean response time from workers are two key points de- rived from the hypercube model. Different types of task assignments are analyzed to minimize workload imbalance and mean response time. Numerical results will be presented.

2 - Achieving Design Flexibility in Crossdock Facilities by Finding Alternative Solutions of Interest

Monique Guignard, University of Pennsylvania, Bala Cynwyd, PA, United States, Steven Orla Kimbrough

For some optimization problems, assuming maximization and <= constraints, a "good" solution may have different characteristics: A. feasible, with high objective function value, B. feasible, with some high slack values, and acceptable objective value, or C. Slightly infeasible, with some high slack values and high objective value. Standard optimization only produces type A solutions. We compare two approaches for assigning trucks to doors in a rectangular crossdock facility in terms of ease of generation and attractiveness of the "good" solutions.

3 - Formulation and Solution of a Master Production Planning Problem

Sunderesh S. Heragu, Regents Professor, Head, Humphreys Chair, Oklahoma State University, 322 Engineering North, School of Industrial Engineering & Management, Stillwater, OK, United States, sunderesh.heragu@okstate.edu, Baski Balasundaram, Austin Buchanan, Yajun Lu, Hosseinali Salemi, Hao Pan

We present an analytical approach for master production planning of pickle products at a top 10 private label food and beverage company. A linear programming model is formulated that maximizes economic profit and customer service levels by taking a combination of time-varying raw material costs, transportation/inventory costs, monthly production costs at each across multiple manufacturing plants, and revenues at the SKU-level into account. The mathematical model is implemented in Python along with commercial optimization solver Gurobi. The master planning model can also be extended to estimate crop intake needs for strategic planning.

■ SD51

CC- Room 620

Aviation Applications Section: Award Finalists

Sponsored: Aviation Applications

Sponsored Session

Chair: Susan Hotle, Virginia Tech, Blacksburg, VA, 24061, United States

Co-Chair: Farbod Farhadi, Roger Williams University, Bristol, RI, 02809, United States

Co-Chair: Laura Kang, Boeing Company, Seattle, WA, 98124-2207, United States

Co-Chair: Soheil Sibdari, Laura Kang, Boeing Company, Seattle, WA, 98124-2207, United States

1 - Airport Capacity Management Towards a Slot Allocation Modelling Approach Compliant with IATA Rules

Nuno Ribeiro, Singapore University of Technology and Design, Singapore

Air traffic demand has grown to exceed available capacity during extended parts of each day at many of the busiest airports in the world. Absent opportunities for capacity expansion, this may require the use of demand management measures to restore the balance between scheduled traffic and available capacity. We develop an original modelling approach aimed to advance existing slot allocation tools and procedures at the largest airports in the world. For that purpose, we formulate a novel integer programing model of slot allocation fully compliant with the WSG rules. The model - named Priority-based Slot Allocation Model (PSAM) - develops an original and efficient mathematical formulation that enables its implementation using exact optimization methods at airports at least with twice the size as previously considered.

2 - A Stochastic Integer Programming Approach to Air Traffic Scheduling and Operations

Kai Wang, MIT Sloan School of Management, Cambridge, MA

This paper provides an original integrated approach that jointly optimizes scheduling interventions in the strategic level and ground-holding operations in the tactical level across airports networks, under operating uncertainty. It is formulated as a two-stage stochastic integer program. We develop new exact solution algorithms based on dual integer cuts and neighborhood search, which are shown to provide optimal, or near-optimal solutions in reasonable computational times. Case study results identify opportunities in network demand management.

3 - Airline Timetable Development and Fleet Assignment Incorporating Passenger Choice

Keji Wei, Dartmouth College, Hanover, NH

We introduce an original integrated optimization approach to comprehensive timetabling and fleet assignment under endogenous passenger choice. An original multi-phase solution approach and several acceleration heuristics are proposed. Our solution approach significantly outperforms direct implementation using a commercial solver. Computational results using a major airline's network suggest that our overall modeling and computational approach results in significant profit improvements within a realistic computational budget. We present several extensions for strategic decision-making.

4 - Runway Scheduling during Winter Operations

Maximilian Pohl, TU Munich, Munich, Germany

We present an optimization model for the runway scheduling problem considering winter operations. During periods of snowfall, runways have to be intermittently closed in order to clear them from snow, ice, and slush. We propose an integrated optimization model to simultaneously schedule snow removals and aircraft on multiple runways. To improve computational times, we develop pruning rules and valid inequalities. A computational study based on real-world data shows that our approach significantly reduces weighted aircraft delay and computes high quality runway schedules within a few seconds.

■ SD52

CC- Skagit 1

Approximation Algorithms for Dynamic Pricing and Assortment Problems

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Antoine Desir

1 - Multi-product Dynamic Pricing with Limited Inventories under a Cascade Click Model

Stefanus Jasin, University of Michigan, 2836 Barclay Way, Ann Arbor, MI, United States, sjasin@umich.edu, Sajjad Najafi, Izak Duenyas, Joline Uichanco

We consider a dynamic pricing problem where products are displayed on a list and have limited inventories. Upon arrival, customers start browsing from the top of the list, deciding at each step whether to buy, not buy, leave the system, or continue browsing. This is the popular Cascade Click model in the literature. We study the property of the optimal price policy. We also study a deterministic approximation of the problem, develop heuristic policies and show that they are asymptotically optimal.

2 - Assortment Optimization under the Paired Combinatorial Logit Model

Heng Zhang, University of Southern California, San Gabriel, CA, United States, hengzhang24@gmail.com, Paat Rusmevichientong, Huseyin Topaloglu

We consider uncapacitated and capacitated assortment problems under the paired combinatorial logit model, where the goal is to find a set of products to maximize the expected revenue obtained from a customer. In the uncapacitated setting, we can offer any set of products, whereas in the capacitated setting, there is an upper bound on the number of products that we can offer. Even the uncapacitated assortment problem is strongly NP-hard. To develop an approximation framework for our assortment problems, we transform the assortment problem into an equivalent problem of finding the fixed point of a function but computing the value of this function at any point requires solving a nonlinear integer program.

3 - An Approximation Algorithm for Network Revenue Management under Nonstationary Arrivals

Mika Sumida, Cornell Tech, New York, NY, 10128, United States, ms3268@cornell.edu, Paat Rusmevichientong, Huseyin Topaloglu

We provide an approximation algorithm for network revenue management problems. In our approximation algorithm, we construct an approximate policy using value function approximations that are expressed as linear combinations of basis functions. We use a backward recursion to compute the coefficients of the basis functions in the linear combinations. If each product uses at most L resources, then the total expected revenue obtained by our approximate policy is at least 1/(1+L) of the optimal total expected revenue. In many network revenue management settings, although the number of resources and products can become large, the number of resources used by a product remains bounded.

4 - Bifurcating Constraints to Improve Approximation Ratios for Online (reusable) Resource Allocation

Jackie Baek, MIT, Cambridge, MA, United States, baek@mit.edu, Will Ma

We improve approximation ratios in online resource allocation problems by bifurcating constraints into matroid constraints and graph constraints. Our work applies to both reusable resources and network revenue management.

■ SD53

CC- Skagit 2

Joint Session RMP/Practice Curated: Innovative Applications of Revenue Management & Pricing

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Pelin Pekgun, University of South Carolina, Columbia, SC, 29205, United States

Co-Chair: Ovunc Yilmaz, University of Notre Dame, South Bend, IN, 46617, United States

1 - Joint Inventory Allocation and Price Optimization Problem

Andrew Vakhutinsky, Oracle Labs, Burlington, MA, United States, andrew.vakhutinsky@oracle.com, Kiran V. Panchamgam, Su-Ming Wu

We examine a retail profit maximization problem with two sets of decision variables: location-specific pricing to sell the merchandise inventory and the amount of inventory allocated from multiple supply centers at potentially different costs. We propose a general iterative approach to solving the problem similar to gradient descent and show its convergence to optimality and describe some special cases commonly encountered in practice. We conclude our presentation by discussing the results of our computational experiments using the data of the Oracle fashion retail customer and share our experience of productizing the algorithm as part of Oracle Retail Price Optimization software product.

2 - Ensemble Methods in Dynamic Pricing

Dirk Sierag, PROS, Houston, TX, United States

In this case study a scalable dynamic pricing method is applied to several datasets. The goal is two-fold: (1) improve forecast accuracy, and (2) optimize prices. The method exploits ensemble techniques to estimate parameters and price-sensitivity functions, which are subsequently used to optimize prices. Along with performance results of our method, we will discuss the impact of feature selection/engineering on these datasets and the relationship between forecasting accuracy and price optimization.

3 - Adding Flights for the Super Bowl? Airline Revenue Management with Price-freeze Options

Xiyuan Ge, University of Washington, Seattle, WA, 98195, United States, xiyuange@uw.edu, Ovunc Yilmaz, Daewon Sun

Mega sporting events such as the Super Bowl are played at neutral locations rather than in one of the competing teams' host city. In this paper, we study the pricing and capacity decisions for an airline selling tickets for the neutral location from the cities with semi-final teams. We propose a novel pricing mechanism called "price-freeze options" where customers can pay a fee to reserve the right (and obligation) to purchase an airline ticket at the pre-semi-final price if their team qualifies for the final game.

4 - Dynamic Pricing of Fashionable Products with C2c Marketplaces and Strategic Consumers

Mingcheng Wei, University at Buffalo, 326C Jacobs Management Center, Buffalo, NY, 14260, United States, mcwei@buffalo.edu, Michelle Wu

This paper studies the influence of C2C resale marketplaces on pricing decisions and revenue performance of a capacitated seller selling high-tech or fashion products. We identify conditions under which the resale marketplace could benefit the seller.

■ SD54

CC- Skagit 3

Joint Session RMP/Practice Curated: Mital's Session

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Pratik Mital, Revenue Analytics, Atlanta, GA, 30318, United States

1 - Price Sensitive Inventory Optimization

Pratik Mital, Revenue Analytics, Atlanta, GA, 30324, United States, pmital@revenueanalytics.com

Price and inventory optimization has been the back bone of revenue management in travel and hospitality industries. Traditional way is to optimize price and then allocate inventory based upon the optimized prices. In this work, we bring together these two optimizations into a single step and apply it across rail and cruise industries.

2 - The "Berth" of Revenue Science in Cruising

John A. Harvey, Director, Revenue Science, Holland America Line, Carnival House, Seattle, WA, SO15 1ST, United States

Holland America Line, as part of the Carnival Group, have a long and proud history of providing cruise holidays and experiences which are the "Signature of Excellence". The growth of the cruise industry and associated "big data" brings both challenge and opportunity. This talk introduces the nuances of Revenue Management in cruising and shares some of today's and tomorrow's problems to solve in the ever-evolving Cruise analytics space.

3 - MSRP Portfolio Price Optimization - A Review

Iman Nekooeimehr, Revenue Analytics, Atlanta, GA, 33613, United States

MSRP portfolio optimization refers to jointly optimizing prices of several interacting products, Price portfolios are important in products with different types, options and configurations, like cars, bicycles or TVs. In this presentation, we review some of the existing solutions to this problem.

■ SD55

CC- Skagit 4

Joint Session RMP/Practice Curated: Pricing and Revenue Management Applications at Amazon

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Robert L. Phillips, Amazon, Palo Alto, CA, 94306, United States

1 - Amazon Lockers: Improved Customer Experience with Machine Learning and Mathematical Optimization

Samyukta Sethuraman, Senior Research Scientist, Amazon, Palo Alto, CA, United States, samyukts@amazon.com

Amazon's focus on customer obsession has led to the installment of Amazon lockers, where customers can pick up packages and drop off returns. To manage unknown package dwell times and rising locker delivery rates, Amazon developed a hybrid model for this novel yield management application. The model combines machine learning and mathematical optimization to maximize package deliveries, reduce rejections and improve customer satisfaction. This model resulted in a 9% increase in locker throughput worldwide during the peak holiday season in 2018.

2 - Dynamic Freight Pricing at Amazon

Roger Lederman, Amazon, Seattle, WA, United States

We discuss how automated truckload pricing models helped Amazon extend its supply of carriers, replacing a primarily manual process of negotiating for loads at the last minute. Our pricing algorithm supports one-click tendering for carriers at competitive prices, and allows planners to predict spot capacity costs to create a more efficient schedule of loads. Removing the need for negotiations has created a faster, more convenient process, with transparency to rates for all carriers. The algorithm has been essential to this shift by providing guaranteed rates that consistently reflect the current market, giving carriers the confidence to quickly accept new work when it matches their capabilities.

3 - Dual Sourcing and Pricing for Seasonal Products

Alvaro Maggiar, Amazon.com, New York, NY, United States, maggiara@amazon.com, Alp Muharremoglu, Ali Sadighian

We present a procurement model for highly seasonal products, such as toys or fashion products, which are usually purchased through a combination of import and domestic buys, months ahead of typical vendor lead times. This procurement process differs significantly from more common just-in-time buying, and the decision to split orders between import and domestic channels reflects a trade-off between cost and information gain. We present a dynamic programming approach to the problem that captures the value of information gain by modelling the evolution of forecasts through the Martingale Method of Forecast Evolution, and incorporate pricing decisions during the selling season.

■ SD56

CC- Skagit 5

Topics in Network Revenue Management

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: George Chen

1 - Joint Pricing and Routing in a Network

Pornpawee Bumpensanti, Georgia Institute of Technology, H. Milton Stewart School of Industrial & Sys, Atlanta, GA, United States, Martin Savelsbergh, He Wang

The joint pricing and routing problem considers a transportation network represented by a directed graph, where each edge has a capacity and a linear transportation cost. The decision maker sets price for each origin-destination pair (which determines the amount of flow that needs to be served) and split flow among multiple paths in the network given capacity constraints. The objective is to maximize revenues from serving flows minus transportation costs. We propose two algorithms for this problem: a Frank-Wolfe type algorithm, and a primal-dual algorithm using online learning technique.

2 - On Revenue Management with Strategic Customers Choosing When and What to Buy

Yiwei Chen, University of Cincinnati, Cincinnati, OH, 487372, United States, Nikolaos Trichakis

We consider a network revenue management model with customers who strategically decide when to purchase and which product to purchase. Customers have heterogeneous arrival times, product valuations and value decay rates. The seller aims at finding a pricing policy that maximizes the expected total revenue. We reformulate the problem as a multi-dimensional mechanism design problem. We establish an upper bound by relaxing this problem into a series of one-dimensional problems. We show that a simple fixed price policy achieves a constant competitive ratio relative to this upper bound. Our numerical study shows that our policy is nearly optimal.

3 - Low-regret Online Decision-making via the Bellman Inequalities

Alberto Vera, Cornell University, Ithaca, NY, United States, aav39@cornell.edu, Siddhartha Banerjee, Itai Gurvich

We introduce a framework to construct re-solving policies with the first constant regret guarantees (i.e., additive optimality-loss that is constant in the horizon and resource budgets) for a wide variety of problems, including online resource-allocation, dynamic pricing with discrete price levels, online budgeted probing, and contextual bandits. All our policies are built out of a meta-algorithm, where we first construct a tractable offline benchmark that satisfies a notion we refer to as the Bellman inequalities, and then use this benchmark with re-solving to construct a feasible online policy.

4 - A Primal-dual Learning Algorithm for Personalized Dynamic Pricing with an Inventory Constraint

Ningyuan Chen, Hong Kong University of Science and Technology, Clear Water Bay, Kowloon, Hong Kong, Guillermo Gallego

A firm is selling a product to different types of customers over a finite season with non-replenishable inventory. The type label of an arriving customer can be observed but the demand function associated with each type is initially unknown. The firm sets personalized prices dynamically for each type and attempts to maximize the revenue over the season. We provide a near-optimal learning algorithm when the demand and capacity scale in proportion. The algorithm utilizes the primal-dual formulation and learns the dual optimal solution explicitly. It allows the algorithm to overcome the curse of dimensionality and sheds light on novel algorithmic designs for learning problems with resource constraints.

■ SD57

CC- Yakima 1

Emerging Topics in Emergency Medical Services

Sponsored: Public Sector OR

Sponsored Session

Chair: Marla Lavanya

1 - Identifying Trade Offs in Equity and Efficiency for Simultaneously Optimizing Location and Multipriority Dispatch of Ambulances

Shakiba Enayati, State University of New York, Plattsburgh, Plattsburgh, NY, United States, senay002@plattsburgh.edu, Maria Esther Mayorga, Hector Toro Diaz, Laura Albert

Emergency medical service (EMS) systems provide acute care and possibly transportation to hospitals to patients experiencing medical emergencies. The community expects equitable service from EMS systems. We provide a multicriteria optimization approach aimed at identifying good solutions for several equity and efficiency measures together, based on a joint modeling approach for location and dispatching policy decisions, while considering multiple levels of call priority. We apply our approach to a real world data set. We show that the joint approach provides better solutions than using the common assignment of the closest available ambulance, in particular for the equity criteria.

2 - Contract Design with Information Asymmetry in Emergency Stroke Care Systems

Ruijiu Mao, Purdue University, West Lafayette, IN, United States, mao95@purdue.edu, Nan Kong, Paul Griffin

Stroke treatment is time sensitive and dependent on stroke type. Sending emergency stroke patients to an appropriate care facility level can save time and increase their survival. The stroke type can only be confirmed after a CT scan from primary stroke centers or stroke capable hospitals. We consider a set of contracting mechanisms for coordinating stroke care between the government (Medicaid/Medicare), hospital, and EMS system within a principal-agent framework. EMS decides the corresponding facility level by following its policy set a priori, which can lead to over- or under-treatment. We illustrate how appropriate contract choice varies by factors such as urbanicity.

3 - Optimizing Regional Trauma Network via Bilevel Integer Programming

Shaonan Liu, Dalian University of Technology, China, Dalian, China, hua.zheng.kai@mail.dlut.edu.cn, Nan Kong, Mingzheng Wang, Pratik J. Parikh

In this talk, we consider a problem of optimizing a regional trauma network that minimizes the negative effects of under-triage (to improve social well-being) and over-triage (to reduce spending) errors in the presence of two decision-makers, the government and the hospital system. We present a novel bilevel subsidized network redesign problem and design a branch-and-bound algorithm with an enhanced cut to solve the resultant bilevel integer programming. The numerical experiments with randomly generated instances demonstrate the superiority of our algorithm for medium- to large-sized bilevel integer programming. We also present a case study based on the real data from a Midwest U.S. state.

4 - Optimizing the Coordination of Emergency Medical System and Drone-delivered Automated External Defibrillators Operated by Random Bystanders

Jungeun Shin, University of Illinois Urbana-Champaign, Urbana, IL, United States, jungeun4@illinois.edu, Lavanya Marla, Justin James Boutilier

Drone-delivered automated external defibrillators (AED) are emerging technology for emergency care of out-of-hospital arrest due to its mobility for quick response to emergency requests. However, AED cannot be properly used unless any bystander is available at the scene. In this study, we consider adding drone-delivered AED to the existing ambulance services and develop an optimization framework to minimize additional required drones while the ambulance-drone cooperative EMS system guarantees a required response time when bystanders' availability is stochastic.

■ SD58

CC- Yakima 2

IE/OR for Health and Education Policy

Emerging Topic: Policy & Government

Emerging Topic Session

Chair: Sze-chuan Suen, University of Southern California, Los Angeles, CA, 90089-0193, United States

1 - Investing in Performance: Information and Merit-based Incentives in K-12 Education

Vanitha Virudachalam, University of Illinois at Urbana-Champaign, Urbana-Champaign, IL, United States, vanitha@wharton.upenn.edu, Sergei Savin, Matthew Steinberg

We study the relationship between information on student performance and monetary incentives for teachers using a two-period principal-agent model, where the school district (principal) chooses whether to invest in interim assessments and how much merit-based compensation to offer to teachers, while the teachers (agents) decide on the level of effort to exert in each period. Two-state Markovian dynamics describe the evolution of student performance. We establish that there are some settings where the provision of additional information about the student mid-year performance has a demotivating effect on teachers.

2 - Diversion Programs for Drug Offenders: Health Outcomes and Cost-effectiveness

Margaret L. Brandeau, Stanford University, Management Science and Engineering, Stanford, CA, United States, brandeau@stanford.edu, Cora Bernard

Diversion programs aim to divert low-level drug offenders toward community care resources, avoiding criminal justice costs and disruptions in treatment for HIV, HCV, and drug abuse. We assessed the health benefits and cost-effectiveness of a jail diversion program for low-level drug offenders. We find that such a program will reduce HIV and HCV incidence, overdose deaths among people who inject drugs, and jail population size. Moreover, such a program is likely to be cost-effective, generating savings in the criminal justice system while only moderately increasing healthcare costs.

3 - Cost-effectiveness Analysis of Pre-art Drug Resistance Testing for HIV-infected Children in Kenya

Mutita Siriruchatanon, University of Washington, Seattle, WA, United States, siriruc@uw.edu, Shan Liu, Horacio A. Duarte

WHO guidelines recommend empiric efavirenz-based antiretroviral therapy (ART) for HIV-infected children initiating treatment at ≥ 3 years old. However, the prevalence of efavirenz-associated pretreatment drug resistance (PDR) is high in this population. We developed and calibrated a model that simulates natural disease progression and treatment for HIV-infected children in Kenya. We simulated three care strategies for PDR testing among children ≥ 3 years old: 1) no testing; 2) testing with oligonucleotide ligation assay (OLA), a low-cost point-of-care test; and 3) testing with consensus sequencing (CS). PDR testing with OLA is a cost-effective alternative to PDR testing with CS.

4 - Cost-effectiveness of a Vaccines under Development

David W. Hutton, University of Michigan, Ann Arbor, MI, 48105, United States, dwhutton@umich.edu

Various vaccines are under development. When they become available, organizations like the Advisory Committee on Immunization Practices will want to be ready to make recommendations about who should receive these vaccines (if anyone). We discuss the approach of using mathematical models to evaluate the cost-effectiveness of newly-developed vaccines in various populations with different risks. We discuss how models can be useful to evaluate under what conditions (vaccine price and efficacy) vaccines would be considered cost-effective. We show this with examples of norovirus and respiratory syncytial virus.

5 - Introduction of Store Choice in India's Food Security Program – Implications on Demand Distribution, Replenishment Policy and Welfare Enhancement

Maya Ganesh, Student, Indian School of Business, Hyderabad, India, Maya_Ganesh@isb.edu, Sarang Deo, Sripad K. Devalkar

India's food security program has traditionally suffered from poor service levels due to local monopoly of retail stores. Advances in technology have enabled introduction of store choice to empower beneficiaries. However, absence of data before implementation makes it difficult to evaluate impact of choice on program performance. We develop a structural model of beneficiaries' store choice, use its estimates to construct baseline scenario (no choice) & evaluate impact of choice. Further, we demonstrate empirically that this impact is mediated by demand variability at store level. Based on this insight, we establish the need for complementary supply side changes for an effective intervention.

■ SD58a

CC- Chelan 1

4:30-5:15 Litic Software / 5:15-6:00 Optimization Firm

Vendor Tutorial

1 - LITIC, the Next Generation Decision Analytics Platform

John Poppelaars, Litic Software, Berendrecht, Netherlands

LITIC is a new, cloud based, decision analytics platform that will increase your productivity as an Operations Research consultant significantly. It supports you throughout the model development cycle, starting from data all the way through delivery of the decision support app, without the need to switch to other tools. It will let you bypass the coding hurdles you encounter every day and lets you fulfill customer requirements without the need to become an advanced application developer. During the tutorial John Poppelaars, OR consultant with over 30 years of practical experience and a 2012 Edelman laureate, will demonstrate the use of LITIC in solving client challenges, also touching upon best practices of OR consulting. Using examples from his own practice John will illustrate how LITIC has made a difference in supporting his clients. John will touch upon data analysis, interactive modelling support of LITIC, scenario and sensitivity analysis and app development, illustrating the speedup LITIC can bring to decision analytics in practice.

2 - ALAMO for Data Analytics and Machine Learning

Yash P. Puranik, Carnegie Mellon University, 5000 Forbes Avenue, Doherty Hall, Pittsburgh, PA, 15213, United States, Nick Sahinidis

The Optimization Firm will present a tutorial on the new ALAMO software for building models from data. ALAMO's innovative optimization and sampling technology uses data from experiments or simulations to generate interpretable models. ALAMO ensures that the models are as simple and accurate as possible while also satisfying physical constraints on the response variables. This tutorial will describe ALAMO's biggest features that make it uniquely suited for machine learning and analytics. We'll also present results comparing ALAMO to standard machine learning methods. Everyone has free access to ALAMO before its commercial launch.

■ SD59

CC- Chelan 2

Special Session: Gaussian Processes: A Discussion on Theory and Applications in Machine Learning and Computer Experiments

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Raed Al Kontar, University of Michigan, Ann Arbor, MI, 48109, United States

Co-Chair: Rui Tuo, College Station, TX, 77845, United States

1 - Gaussian Processes: A Discussion on Theory and Applications

Raed Al Kontar, University of Michigan, IOE 2769, Ann Arbor, MI, 48109, United States, alkontar@umich.edu

In this talk, we discuss recent methodological advances in Gaussian process regression for computer experiments.

2 - Gaussian Processes from a Computer Experiments Perspective

Rui Tuo, Texas A&M University, College Station, TX, United States, ruituo@tamu.edu

Data science in computer experiments mainly focuses on data collection, surrogate modeling, statistical inference, and decision making for complex computer simulation problems. Gaussian process regression serves as an important type of surrogate models in computer experiments. Besides using the usual kriging methods, we will discuss the following specific problems: 1) design of experiments; 2) non-stationary Gaussian process models; 3) approximation theory for Gaussian process regression.

■ SD59a

CC- Chelan 3

Risk Analysis I

Contributed Session

Chair: Navid Ahmadian, University of Houston, Houston, TX, United States

1 - Research on Construction Risk Early Warning of High-speed Railway in Hard and Dangerous Mountainous Areas Based on Extension Theory

Junxiang Xu, South West Jiaotong University, Chengdu, China, 1933348984@qq.com, Jin Zhang, Hui Dong

Based on the analysis of the research status of risk assessment methods for railway construction in mountainous areas at home and abroad, this paper establishes the index system of risk early warning for high-speed railway construction, formulates the criteria of risk early warning classification, constructs a risk early warning model based on extension theory, gives weight value by using combination assignment method, and obtains the correlation function value of early warning object and early warning grade. Taking Sichuan-Tibet railway key tunnel construction project as an example, the applicability of the model and calculation method is verified.

2 - Heterogeneous Risk Preferences in Community-based Electricity Markets

Fabio Moret, Technical University of Denmark (DTU), Lyngby, Denmark, fmoret@elektro.dtu.dk, Pierre Pinson, Athanasios Papakonstantinou

Clearing decentralized electricity markets where agents can negotiate their energy procurement individually, is a complex process further complicated by the uncertainty associated with distributed energy sources. Each agent has subjective criteria in how they appraise risk, leading to heterogeneous risk attitudes that can impact market outcomes and the corresponding payments. We introduce a notion of fairness and build upon it to develop risk hedging mechanisms in the form of financial contracts in order to mitigate the impact of risk. We then evaluate their impact on market equilibrium and show that by trading financial products, more fair market equilibria are achieved.

3 - Perceived Environmental Risk and Strategic Changes: Moderating Effects of TMT Heterogeneity

Rui Wang, University of Science and Technology of China, Hefei, China, wangrr@mail.ustc.edu.cn

Analyzing data from 182 publicly listed firms in China from 2012 to 2018, we find that perceived environment risk complexity plays a positive role to strategic changes, while perceived environment risk dynamism diminishes it. We also find that the negative effect of perceived environment risk complexity is weakened when its dynamism is high, or accentuated when TMT functional background heterogeneity is large. In addition, the positive effect of perceived environment risk dynamism is attenuated when the TMT functional background heterogeneity is high. We discuss our contributions to research on corporate external risk sensing, dynamic management capability and corporate strategic behavior.

4 - A New Perspective on Supplier Risk Mitigation Strategies

Vishwakant Malladi, Indian School of Business, Mohali, Punjab, India, vishwakant_malladi@isb.edu

Frequency and duration are two disparate dimensions of supplier risk. Risk mitigation investments can be directed to improve either of them. In this paper, we consider the two dimensions independently and study the impact of each of these dimensions on the supply chain. We show that a retailer is more concerned with the duration of disruptions than with the frequency. Moreover, we also show that the supplier and retailer have conflicting interests with respect to risk mitigation investments. Finally, we also investigate the impact of supplier risk dependence on the supply chain.

5 - Optimized Certainty Equivalent Risk Measures as Parameterized Risk Families and Their Decomposition Into CVaR and Density Estimation

Alexander Mafusalov, FedEx Express, Memphis, TN, United States, sasha.mafusalov@gmail.com

This paper considers a general convex regret/error/utility measure, under a condition of asymptotic linearity. A parametric 0-1 family of risk quadrangles corresponds to that measure. It is proved that there exists a probability distribution mapping, mean-preserving under certain conditions, such that the described family of risk quadrangles for a random variable coincides with the family of quantile-based quadrangles for the mapped distribution. Additional functionals (buffered probability, Lorenz curve, shortfall risk), interconnections, and particular cases studied. This research draws a strong connection between risk minimization and density estimation.

6 - A Unified Approach for Network Resiliency Quantification Assessment and Improvement

Navid Ahmadian, University of Houston, Houston, TX, United States, nahmadian@uh.edu, Gino J. Lim, Jaeyoung Cho

We propose a quantitative approach for measuring the resiliency of network components and the network itself. First, the component resiliency is defined as a function of criticality, disruption frequency, disruption impact, and recovery time. The component resiliency reflects the effect of component disruption on the network. Then, the network resiliency is measured by the resiliency of the weakest component in the network. Hence, enhancing the network resiliency is possible through reinforcing weakest components in the network.

■ SD60

CC- Chelan 4

QSR Best Paper Competition

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Hui Yang

Co-Chair: Bianca Maria Colosimo, Politecnico di Milano, Milan, I-20156, Italy

Co-Chair: Arman Sabbaghi, Purdue University, West Lafayette, IN, United States

1 - Spectral Autoencoder for Anomaly Detection in Attributed Networks

Yuening Li, Texas A&M University, College Station, TX, United States, Xiao Huang, Jundong Li, Mengnan Du, Na Zou

We propose a spectral convolution and deconvolution based framework - SpecAE, to project the attributed network into a tailored space to detect global and community anomalies. SpecAE leverages Laplacian sharpening to amplify the distances between representations of anomalies and the ones of the majority.

2 - Identifying the Influential Inputs for Network Output Variance Using Sparse Polynomial Chaos Expansion

Zhanlin Liu, University of Washington, Seattle, WA, United States, Ashis G. Banerjee, Youngjun Choe

We propose a novel model to identify the process inputs that influence the process output's variance significantly for a class of processes represented as directed acyclic networks. Theoretical analysis proves the convergence of model prediction. The model's superior efficiency over a benchmark method is empirically validated on two manufacturing processes.

3 - Collusion Detection and Ground Truth Inference in Crowdsourcing for Labeling Tasks

Changyue Song, University of Wisconsin-Madison, Rm 3221, Mechanical Engineering Building, 1513 University Ave, Madison, WI, 53715, United States, Kaibo Liu, Xi Zhang

This paper aims at inferring the ground true labels based on worker-generated noisy labels under worker collusion in crowdsourcing systems. Specifically, we propose a penalized pairwise profile likelihood method with the adaptive LASSO penalty for collusion detection. Theoretical properties are investigated that guarantee the asymptotic performance of the proposed method.

4 - Transfer Learning using Informative Structure Priors in Ordered Graphical Models

Chao Wang, University of Wisconsin-Madison, Madison, WI, 53706, United States, Xiaojin Zhu, Shiyu Zhou, Yingqing Zhou

In this paper, a structure learning framework for ordered block model with limited data samples is proposed. The method constructs an informative structure prior to rigorously reveal commonalities among heterogeneous data from different processes to benefit the learning in complex systems. The method is validated with real car assembly processes.

■ SD61

CC- Chelan 5

Maintenance and Reliability Models for Technical Systems

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Cristiano Alexandre Virginio Cavalcante

1 - A Hybrid Maintenance Policy Based on Operation Time and Shocks Counting for Protection Systems

Alexandre Alberti, UFPE - Universidade Federal de Pernambuco, -, Brazil, alexandre.emc091@gmail.com, Cristiano Cavalcante, Shaomin Wu

We consider a protection system that presents an inherent deterioration process and over which demands act as shocks, which can result in a sudden increase in the failure or defect rate, which is a realistic scenario. We propose a hybrid inspection and preventive replacement policy that considers decision variables related to the operating time and the number of shocks observed, and present an application in the context of electrical energy substations. We also investigate the effects of imperfect maintenance.

2 - Integrated Preventive Maintenance and Quality Control Inspection in an Imperfect Production System

Rodrigo Sampaio Lopes, Assistant Professor, Federal University of Pernambuco, Caruaru, PE, Brazil, rodrigoengep@gmail.com, Cristiano Cavalcante

In this study, the influence of a quality inspection policy on an imperfect production system is modelled. The inspection policy is imperfect, permitting type I and type II errors. After each production cycle, preventive maintenance is performed. In case of failure in the production process before the cycle's end, a minimal repair is indicated. The model is formulated with the objective of minimizing the total cost expected per item while considering an average outgoing quality constraint. The results indicate that the probability of type I and type II inspection errors has a significant impact on optimal production and the percentage of items inspected.

3 - A Study of the Effect of Quality of Maintenance in Opportunistic Maintenance Models.

Cristiano Cavalcante, Universidade Federal de Pernambuco, Rua Antonio de Castro N. 61, Apartment 701, Recife Pernambuco, 52070-080, Brazil, cristianogesm@gmail.com, Mônica Marsaro, Alexandre Alberti

The maintenance has being recognized as a strategical function inside the organizations. This is because provide effective maintenance planning, meeting the appropriated level of quality of this maintenance is become challenging. Therefore, Opportunistic maintenance is a way to increase the performance of a system, finding a moment where this action will not reverberate in downtime. We proposed two maintenance models that consider opportunistic maintenance and errors in inspections. Model 1 considers if the component is indicated be defective (false or true positive) it will be renewed, while in Model 2 the component will only be replaced in a double check structure.

4 - A Framework for Building Multicriteria Decision Models in Reliability and Maintenance Context

Adiel Teixeira De Almeida, Universidade Federal de Pernambuco, Cx Postal 7462, Recife PE, 50630-970, Brazil, adielta@gmail.com, Lucia R. Roselli

Considering the role Reliability and Maintenance (RM) may play in any organization, the decision-making process is relevant for the strategic success. Building decision models for RM context is an important issue, particularly those with multiple objectives. This paper presents a framework for building multicriteria decision models in the RM Context. Classification of multicriteria (MCDM/A) methods is given, with concerns related to choosing a method, considering the DM's compensatory and non-compensatory rationality, and including Multi-Attribute Utility Theory (MAUT) and outranking methods (ELECTRE and PROMETHEE). The framework is presented with some applications already done.

■ SD62

CC- Tahoma 1

Stochastic Models in Healthcare

Sponsored: Health Applications

Sponsored Session

Chair: Oguzhan Alagoz, University of Wisconsin-Madison, Madison, WI, 53706, United States

Chair: Liz Scaria

1 - Cholesterol Follow-up Policy in the Context of Preventive Treatment of Cardiovascular Disease

Daniel Felipe Otero Leon, PhD Student, University of Michigan, Ann Arbor, MI, United States, dfotero@umich.edu, Brian T. Denton, Mariel Sofia Lavieri

Preventing chronic diseases is an essential aspect of medical care for healthy patients, but deciding when to collect information, such as the patient's cholesterol levels, is difficult. Measuring too frequently may be unnecessary and costly; on the other hand, measuring too infrequently means the patient may forgo needed treatment and experience adverse events related to the disease. We present results from estimating a stochastic model based on longitudinal data for cholesterol in a large cohort of patients seen in the national Veterans Affairs health system. We further use this model to study policies for when to collect measurements to assess the need for cholesterol lowering medications.

2 - Accommodating Demand Surges via Proactive Staff-Planning in the Emergency Department

David Rea, University of Cincinnati, Cincinnati, OH, 45220, United States, readj@mail.uc.edu, Craig Froehle

While most services can influence the timing of demand (e.g., via appointment systems or pricing), Emergency Departments (EDs) need to accommodate all patients on arrival. While relative rare, demand surges (a sudden rise in patient-care needs) are known to result in long-lasting operational bottlenecks. This research conceptualizes demand surges as observations in the tail of a distributional forecast. The activation of additional (back-up) staff in anticipation of demand surges is suggested as a strategy for combating ED crowding. Using substantial primary data, we test the hypothesis that this proactive activation of backup will result in consistently lower patient waiting times.

3 - Cost Effectiveness of Depression Screening for General Adult Population

F.Melike Yildirim, Georgia Institute of Technology, Atlanta, GA, United States, fmyildirim@gatech.edu, Pinar Keskinocak, Julie L. Swann

U.S. Preventive Services Task Force (USPSTF) did not find enough evidence about the optimal depression screening intervals for general adults in primary care. However, undiagnosed and untreated depression decrease the quality of life and increased the risk of suicide, therefore the routine screening has potential impact on improvement of progression of disease. In this study, we evaluate age and gender specific depression screening intervals for US adult population. The cost-effectiveness of screening can lead to policy makers and insurance companies to expand the coverage for depression screening in primary care.

4 - An Agent-based Simulation of Hospital Acquired Clostridioides Difficile Infection

Elizabeth Scaria, University of Wisconsin-Madison, University of Wisconsin, Madison, WI, United States, scaria@wisc.edu, Oguzhan Alagoz, Nasia Safdar

Clostridioides difficile infection (CDI) is one of the most common healthcare associated infections. Preventing CDI transmission in healthcare settings involves system-level behavioral interventions, such as environmental disinfection, hand hygiene, and antibiotic stewardship, implemented in bundles. Incomplete knowledge of CDI transmission dynamics hinders decision makers' ability to select optimal interventions. We develop an agent-based simulation model of CDI transmission to assess and compare the relative effectiveness of infection control interventions. Our model provides data for decision makers to select optimal infection control interventions.

5 - Dynamic Patient Routing with Nurse Workload Considerations

Siddhartha Nambiar, North Carolina State University, Raleigh, NC, 27603, United States, snambia@ncsu.edu, Maria Esther Mayorga

While nursing workload has been studied extensively in human factors and other fields, there's a gap (and lack of consensus) in analytics and decision science regarding how to objectively quantify workload and how to use it effectively in an analytic framework. To this end, we develop a multi-class, multi-server queueing model that routes incoming patients to one of several different server pools in an Emergency Department (ED) setting. The routing is performed such that the total time spent by the patient in the system is minimized and the workload experienced by the servers (nurses) is efficiently managed.

■ SD63

CC- Tahoma 2

HAS- Health IT and Operations Management

Sponsored: Health Applications

Sponsored Session

Chair: Susan F Lu, Purdue University, West Lafayette, IN, United States

1 - The Zocdoc Effect: How Does Online Information Impact Appointment Availability in Outpatient Care?

Yuqian Xu, University of Illinois at Urbana-Champaign, Champaign, IL, United States, Mor Armony

With the rapid development of online technology, patients are now exposed to a lot of information about doctors before making appointments. This increasing availability of information raises questions regarding the impact of online channels on patients' valuation and doctors' service incentives. In this paper, we propose a queueing model to study the impact of online information on patients and doctor's decisions.

2 - The Impact of Information Technology and Communication on Medical Malpractice Lawsuits

Sharma Luv, University of Southern California, Columbia, SC, United States, Luv.Sharma@moore.sc.edu, Carrie Queenan

Health care organizations have substantially invested in Health Information Technology (HIT) as part of an effort to improve quality. However, many hospitals fail to generate positive returns on this significant investment, based on reimbursements for quality measures through the Affordable Care Act (ACA). Given the high cost of lawsuits, we investigate if HIT adoption reduces lawsuits, and their attendant costs, as another consideration in HIT payoffs.

3 - Does underuse Variation in Test-ordering Practice Relate to Higher Subsequent Care-delivery Cost?

Seokjun Youn, The University of Arizona, Tucson, AZ, United States, syoun@email.arizona.edu, Gregory R. Heim, Subodha Kumar, Chelliah Sriskandarajah

To examine how variation in clinical practice relates to hospital operational performance, we propose a novel measure of practice variation using inpatient discharge data. We find that hospitals may be improperly rewarded for quality improvements if practice variation is ignored, implying that incentives/penalties for hospital operations should be designed to account for such effects. Further, we find differential impacts of underuse variation in test-ordering practice on test-ordering cost and subsequent care-delivery cost. Restrictive reimbursement rules on test-ordering practice are undesirous, as they may result in even higher eventual total care-delivery spending.

4 - The Value of Health It Interoperability: Evidence from Interhospital Transfer of Heart Attack Patients

Yao Li, Tsinghua University, Beijing, China, liy36.15@sem.tsinghua.edu.cn, Lauren Xiaoyuan Lu, Susan F. Lu, Jian Chen

We empirically investigate the effects of health IT interoperability and health information exchange on the interhospital transfer of heart attack patients. Using the NY State ED and Inpatient Databases and HIMSS Database, we characterize the effects in terms of the speed of the transfer process and the health outcome and service utilization of transferred patients.

■ SD64

CC- Tahoma 3

Meet the Editors for Healthcare Research

Sponsored: Health Applications

Sponsored Session

1 - Meet the Editors for Healthcare Research

Moderator: Hui Zhao, The Pennsylvania State University, Smeal College of Business, University Park, PA, 16802, United States

In this special panel session, you will hear from editors in departments publishing healthcare research from many of our major journals, representing a variety of outlets to healthcare research, followed by questions and answers.

Panelists:

- Morris A. Cohen, University of Pennsylvania, Wharton School, Philadelphia, PA, 19104, United States
- Greg Zaric, Ivey Business School, Ivey Business School, London, ON, N6G 0N1, Canada
- Stefan Scholtes, University of Cambridge, Judge Business School, Trumpington Street, United Kingdom
- David Dobrzykowski, University of Arkansas, Sam M. Walton College of Business, Fayetteville, AR, 72701, United States
- Andrew Schaefer, Rice University, Houston, TX, 77005, United States
- Sanjay Mehrotra, Northwestern University, Evanston, IL, 60208-3119, United States
- Ozlem Ergun, Northeastern University, Mechanical and Industrial Engineering, Boston, MA, 02115, United States

■ SD65

CC- Tahoma 4

Empirical Research in Various Healthcare Operations

Sponsored: Health Applications

Sponsored Session

Chair: Rachna Shah, University of Minnesota, Minneapolis, MN, 55455, United States

1 - Evaluating the Profit Quality Link in Nursing Homes

Alison Clement, University of Minnesota, Minneapolis, MN, United States, cleme558@umn.edu, Kevin W. Linderman, Rachna Shah

The health economics literature has repeatedly investigated the link between a nursing homes profit status (for profit or not for profit) and quality. These studies have had inconsistent results, demonstrated that there is not a significant difference in profit margin between for profit and not for profit nursing homes, and assumed that nursing homes are rational profit maximizers. I draw on the behavioral theory of the firm to propose that the link between profit and quality depends not only on the profit status but also the expected performance compared to aspirations.

2 - Diminishing Effects of EHR in USA Hospitals

David Dobrzykowski, University of Arkansas, Fayetteville, AR, United States, dddobrzy@uark.edu, Bogdan C. Bichescu, Randy V. Bradley, Kang Lee, Renee Pratt, Antoinette Smith

Most hospitals in the USA have now adopted some form of electronic health records (EHR) while reporting varying degrees of success. Our study examines how EMR adoption influences individual measures of patient experience over time as hospitals adopt increasingly sophisticated applications. We reveal important curvilinear relationships and tipping points when hospital leaders might expect diminishing returns of patient experience.

3 - Drivers of Emergency Department Boarding

Arshya Feizi, Boston University, Boston, MA, United States, afeizi@bu.edu, Jillian Berry Jaeker, William E. Baker

One of the key reasons for emergency department (ED) overcrowding is boarding patients. Boarding occurs when admitted patients must wait for prolonged periods of time the ED pending their transfer. We investigate the systematic and behavioral causes of boarding empirically.

4 - Quality Healthcare: Patient Flows with Queue Limitation

Richard J. Schonberger, Seattle, WA, 98004, United States

This presentation advocates broad application of queue-limitation (QUEL) methodologies for enabling quick, queue-less response along the multiple flow paths leading to and involving patients. They apply virtually throughout the healthcare organization: wait-free availability/fetching of records, meds, instruments, supplies, imaging, blood, and so on—with key methodologies focused on quick, queue-limited response and patient safety.

5 - How Continuity in Service Impacts Process Control: Evidence from a Primary Care Setting.

Vishal Ahuja, Southern Methodist University, Cox School of Business, Dallas, TX, United States, vahuja@smu.edu, Bradley R. Staats, Carlos Alvarez

In service operations where customers have repeated interactions with service providers, it is critical to understand the importance of maintaining continuity of service, whether customer-types with complex needs need to be prioritized and can there be too much continuity. We study these questions in the context of healthcare - in particular, we study the impact of continuity of service on process control as measured by coefficient of variation of lab measures.

■ SD66

CC- Tahoma 5

Design of Healthcare Strategies under Population Heterogeneity

Emerging Topic: Personalized Health

Emerging Topic Session

Chair: Hadi El-Amine, George Mason University, Fairfax, VA, 22030, United States

1 - A Reinforced Learning Framework for Dynamic Prediction and Management of Type 2 Diabetes Patients

Syed Hasib Akhter Faruqui, University of Texas-San Antonio, San Antonio, TX, United States, Adel Alaeddini, Jing Wang

Type 2 diabetes mellitus (T2DM) is a major health problem. Self-management of lifestyle is essential for glycemic control, and to prevent diabetes complications. Mobile-based health data can play an important role in lifestyle management and control of T2DM. We propose a Reinforcement learning model (agent) that monitors daily lifestyle data of a patient including diet, physical activity, weight, and glucose level and provides an optimal individualized self-management regiment. The model also alerts patients of lifestyle choices that may hinder their progress in attaining weight and glucose level control thus helps patients better adhere to a self-management lifestyle for control of T2DM.

2 - Learning Curve Effects and Cost Effectiveness Analysis in Precision Medicine

Manuel A. Nunez, Associate Professor, University of Connecticut, Vernon, CT, United States, mnunez@business.uconn.edu, Yucheng Chen

Precision medicine is a high-cost complex medical procedure that provides targeted treatments according to individual characteristics of each patient. We present a cost-effectiveness dynamic model to assess learning curve effects in cost reduction through interaction with centralized database repositories. We also consider public policy consequences.

3 - Optimal Clustering of Frequency Data with Application to Disease Risk Categorization

Hadi El-Amine, George Mason University, Fairfax, VA, 22030, United States, helamine@gmu.edu, Hrayer Aprahamian

We provide a novel clustering procedure for a special type of data, known as frequency data. Our interpretation of the data set as a discrete distribution allows us to extract statistical information which we embed within an optimization framework. Our analytical results of the resulting difficult combinatorial optimization problem allow us to construct exact algorithms that converge to the optimal solution in quadratic time. In addition, in order to handle larger data sets, we provide two hierarchical heuristic algorithms that run in linear time. Our case study on HIV risk categorization demonstrates substantial benefits of our proposed clustering scheme over current practices such as k-means.

4 - Optimal Test Selection for the Screening of Heterogeneous Populations

Hrayer Aprahamian, Texas A&M University, College Station, TX, United States, hrayer@tamu.edu, Hadi El-Amine

We study the design of large-scale group testing schemes under a heterogeneous population, and with the availability of multiple tests. The objective is to classify the population as efficiently and accurately as possible. Our approach examines components often neglected in the literature, such as group size dependent costs, and the possibility of no testing. By developing key structural properties of the resulting problem, we are able to reduce it to a network flow problem. We then provide results that facilitate the construction of the graph and provide a polynomial time algorithm. Our case study, on the screening of HIV in the US, demonstrates the substantial benefits of the proposed approach.

■ SD67

S- Virginia

CS and OR Interface

Contributed Session

Chair: Mehmet Kolcu, Wayne State University, Clinton Township, MI, United States

1 - Training Generative Networks Using Random Discriminators

Babak Barazandeh, University of Southern California, Los Angeles, CA, United States, barazand@usc.edu, Meisam Razaviyayn, Maziar Sanjabi

Generative Adversarial Networks (GANs) have drawn a lot of attention for learning the underlying distribution of data. Despite their wide applicability, training GANs is notoriously difficult. This difficulty is due to the min-max structure of the problem and the lack of proper tools of solving general min-max problems. In this work, we try to alleviate this problem by proposing a new generative networks that relies on the use of random discriminators instead of adversarial design. This design helps us to avoid the min-max structure and leads to an optimization problem that is stable and could be solved efficiently. The performance of the proposed method is evaluated using both synthetic and real data.

2 - Time for Devopts – Mathematical Optimization in the Age of Agile, Devops. and Cloud Infrastructure

Andrea Cassioli, Maersk Line, Fruebjergvej 3, Symbion Science Park, Copenhagen, 2100, Denmark, Stefan Guericke

In the last years, the gap between solution methods in literature and optimizations running in production has increased. Agile development practices, DevOps and modern cloud-based infrastructure call for a revisit of how optimization software is developed. We review the state-of-the-art, propose a development framework that can be applied across different programming languages and modelling frameworks and test it with an optimization use-case. The framework enables OR experts to continue focusing on solution methods but having the tools to deploy a scalable and reusable optimization application using the latest technologies and thus, increase the acceptance in industry.

3 - An Image-based Approach to Detecting Structural Similarity Among Mixed Integer Programs

Zachary James Steever, University at Buffalo, Buffalo, NY, United States, zjsteeve@buffalo.edu, Chase Murray, Mark Henry Karwan

Operations researchers have long drawn insight from the structure of a mixed integer program's (MIP) coefficient matrix. We propose a new question - can coefficient matrix structure be used to identify similarities between different MIPs? We treat these matrices as pixel map images, and employ computer vision techniques to detect latent structural features therein. These feature vectors are used to measure similarity between images, and consequently, MIP instances. For this introductory analysis, we used the collection of instances in the MIPLIB 2017 (an online repository for MIP instances) as our data set. Results indicate that this may be a promising approach for identifying related models.

4 - Mosel 5: Next Generation Modelling and Application Design Features for Optimization Projects

Susanne Heipcke, Principal Engineer, FICO, Birmingham, United Kingdom, susanneheipcke@fico.com

FICO Xpress Mosel 5 builds out its support of a dynamic and modular structure in the implementation of optimization projects, thus facilitating the collaboration of larger teams (often working in a distributed setting) in the development and maintenance of end-user applications. New features include dynamic handling of packages and the introduction of namespaces, also supported by enhancements to the development environment Xpress Workbench. Considerable performance improvements in the handling of large-scale data have been achieved through new data structures that are presented via examples.

5 - Leveraging Cloud Computing for Solving Large Scale Optimization Problems Using Scaleable Algorithms

Baykal Hafizoglu, FICO, Kennesaw, GA, United States, baykalhafizoglu@fico.com

Large scale optimization problems often cannot be solved using standard mathematical modeling methods (linear/mixed integer programs) due to excessive run times and hardware requirements. In this study, we first demonstrate a generic methodology to develop optimization algorithms, which can scale with additional hardware to reach desired solution quality and run time. We next provide examples of how FICO Xpress-Mosel leverages cloud computing to orchestrate these algorithms.

6 - Joint Predictive and Prescriptive Analytics

Mehmet Kolcu, Wayne State University, Detroit, MI, United States, fl4915@wayne.edu, Alper E. Murat

In traditional learning algorithms, the degree of closeness between true and predicted values generally measures prediction quality. However, these learning algorithms do not consider decision problems where the predictions will be used as uncertain parameters. In other words, standard approaches using point estimates as input in optimization problems miss the connection between predictive and prescriptive algorithms. We propose a new framework evaluating quality of predictions based on the decisions by integrating machine learning algorithms with optimization problems. We aim to find the parameters of learning algorithms within decision problems through bilevel optimization.

■ SD68

S- University

SOLA Student Best Paper Award

Sponsored: Location Analysis

Sponsored Session

Chair: Ismail Capar, Texas A&M University, College Station, TX, United States

1 - A Cyclic Allocation Model for the Inventory-Modulated Capacitated Location Problem

Kayse Lee Maass, Northeastern University, Boston, MA, 02115, United States

Hard capacity constraints have been used for decades in facility location modeling. Yet, in reality, many facilities are able to extend capacity for short periods of time. To address this, we present a cyclic, day-specific allocation approach to assigning demand sites to processing facilities that accounts for short term capacity flexibility. In particular, unprocessed demand in excess of the daily processing capacity is held and processed at the beginning of the following day. We demonstrate that this cyclic allocation and flexible capacity approach reveals cost effective operating policies that take advantage of spatial and temporal correlations in demand and capacity.

2 - Exact Robust Solutions for the Combined Facility Location and Network Design Problem in Hazardous Materials Transportation

Xufei Liu, University of South Florida, Tampa, FL, United States

We consider a bi-level leader-follower problem that simultaneously optimizes facility locations and network design in hazardous materials transportation. The leader intends to reduce facility setup cost and hazmat exposure risk by choosing facility locations and closing road segments. When making such decisions, the leader anticipates the response of the followers who aim to minimize transportation costs. A robust optimization method is used to deal with uncertain hazmat risk and transport demand. We devise an exact algorithm that combines a cutting plane algorithm with Benders decomposition.

3 - Exact Solution of Several Families of Location Arc Routing Problems

Jessica Rodriguez-Pereira, Technical University of Catalonia, Catalonia, Spain

We model and solve several families of location-arc routing problems. The aim is to select the facility locations and to construct a set of routes traversing the required edges, where each route starts and ends at the same facility. The models differ in the objective function and if capacity constraint are included. Alternative formulations with only binary variables are presented and solved by branch and cut. Despite the difficulty of the problems, the numerical results demonstrate the good performance of the algorithm, solving to optimality instances with up to 200 vertices.

4 - Benders Decomposition for Profit Maximizing Hub Location Problems with Capacity Allocation

Gita Taherkhani, University of Waterloo, Waterloo, ON, Canada

We model and solve several families of location-arc routing problems. The aim is to select the facility locations and to construct a set of routes traversing the required edges, where each route starts and ends at the same facility. The models differ in the objective function and if capacity constraint are included. Alternative formulations with only binary variables are presented and solved by branch and cut. Despite the difficulty of the problems, the numerical results demonstrate the good performance of the algorithm, solving to optimality instances with up to 200 vertices.

■ SD69

S- Seneca

Joint Session MSOM/HC/Practice Curated: Empirical Healthcare Operations: Improving Quality and Process Outcomes

Sponsored: Manufacturing & Service Oper. Mgmt/Healthcare Operations

Sponsored Session

Chair: Mehmet U.S. Ayvaci, The University of Texas at Dallas, Richardson, TX, United States

Co-Chair: Ozalp Ozer, The University of Texas at Dallas, Richardson, TX, 7United States

1 - Matching Patients to Providers: A Field Experiment

Diwas S. Kc, Emory University, Goizueta Business School, Atlanta, GA, United States, Kunpeng Zhang

To examine how patients select providers, we conduct a series of field experiments in which the patient sees different characteristics of the provider. This allows us to assess what patients value most in selecting providers. We also examine the resulting effects on the quality of care.

2 - Quality Improvement Spillovers: Evidence from the Hospital Readmissions Reduction Program

Mohamad Soltani, University of Wisconsin-Madison, Madison, WI, 53706, United States, mohamad.soltani@wisc.edu, Robert Batt, Hessam Bavafa

Financial incentives are commonly used to encourage improvements in quality. However, the presence of spillovers can make managing these incentives difficult. We study the spillover effects of a national healthcare quality improvement policy, the Hospital Readmissions Reduction Program (HRRP), on patients and metrics not targeted by the policy. Whereas prior work has shown limited spillover of quality improvement initiatives in manufacturing settings, we find that in the healthcare setting, HRRP led to improvements in the target metric for non-targeted patients. We also find significant improvements in non-targeted measures such as 31-60-day readmissions, length of stay and cost.

3 - Saving Lives with Algorithm-enabled Process Innovation: The Case of Sepsis

Mehmet U.S. Ayvaci, University of Texas at Dallas, Richardson, TX, 75080-3021, United States, mehmet.ayvaci@utdallas.edu, Idris Adjerid, Ozalp Ozer

We study whether and how algorithm-enabled process innovation (AEPI) creates value in the context of an AEPI effort focused on early identification and treatment of a deadly clinical condition known as sepsis. Using a rich set of clinical and nonclinical data from a hospital system, we examine the relationship between sepsis AEPI and patient mortality. Overall, we demonstrate that sepsis AEPI is effective in reducing mortality and it does so through timely diagnostic (i.e., lactates) and therapeutic (i.e., antibiotics) interventions. As time goes by, however, the timeliness of these interventions partially lapses and so does the sepsis AEPI's reduction impact on mortality.

■ SD70

S- Jefferson A

IS Research on Digital Platforms

Sponsored: EBusiness

Sponsored Session

Chair: Marios Kokkodis, Boston College, Chestnut Hill, MA, 02215, United States

1 - Do Corporate Contributions Spur Innovative Activity in Online Crowdsourced Goods? Evidence From the Linux Kernel

Mike Horia Teodorescu, Assistant Professor, Boston College, Chestnut Hill, MA, 02903-4370, United States, teodores@bc.edu, Do Yoon Kim

Despite significant advances in our understanding of the factors that affect corporate provision of digital public goods, the converse question of how corporate participation affects innovation in digital public goods is less understood. In this paper, we test how increased corporate participation affects source code contributions and follow-on innovation in a large open source project. We test whether corporate contributions increase non-corporate contributions or whether they "crowd out" non-corporate contributions. We find that while corporate contributions attract more contributions overall, they also lead to less follow-on innovation.

2 - On the Timing of Registration Request: A Randomized Field Experiment

Ni Huang, Arizona State University, Arizona, Gilbert, AZ, 85233, United States, Probal Mojumder, Tianshu Sun, Jinchi Lv, Joseph Golden

Online commerce websites often request user to register in the online shopping process. Recognizing the challenges of user registration, many websites opt to delay their registration request until the end of conversion funnel (ex-post registration request). Grounding on the nudge theory, our study explores an alternative approach by asking users to register with the website at the beginning of their shopping journey (ex-ante registration request). We conducted a large-scale randomized field experiment in partnership with an online retailer in the U.S. to examine how the ex-ante request affects users' registration decision, as well as short-term conversion and long-term purchase behavior.

3 - Monetary Incentives and Knowledge Spillover: Evidence from a Natural Experiment

Jing Wang, Hong Kong University of Science and Technology, Clear Water Bay, Hong Kong, Gen Li, Kai-Lung Hui

Knowledge sharing is common on the Internet. In this paper, we study the effect of introducing monetary incentives for holding live talks on users' contribution to non-rewarded activity of answering questions on the same online question-and-answer platform. Using a combination of coarsened exact matching and difference-in-differences estimation techniques, we find that introducing paid program creates a positive spillover effect on the hosts' free contributions, specifically, 9.4%-40.8% more answers, in the short run when compared with non-hosts. The paid feature did not result in any significant change in the quality of answers. We suggest reputation building is likely the mechanism underlying the spillover and provide direct evidence that our finding persists in view of competing mechanisms and explanations, such as explicit advertising, reciprocity, and time spillover. Additional analyses reveal that the spillover effect in the long run is negative for short-lived hosts and positive for long-lived hosts, the latter effect gradually tapered off over time. We draw related research and managerial implications.

4 - Can (S)he Code? Gender Bias in an Open Source Software Community

Tingting Nian, University of California, Stern School of Business, Irvine, CA, 10012, United States, tnian@uci.edu

It is well-documented that women are underrepresented across all STEM fields and particularly in computing. Amongst the many factors that impact women's lack of participation in computer science-related fields, previous research identifies the negative stereotype about women's abilities is one of the leading reason. In order to scientifically examine the issue of gender bias in online open source software communities, our study investigates whether and to what extent there exists a gender bias on Stack Overflow. Our results reveal a 10.2% reduction in monthly votes after a female user reveals her gender, statistically significant at the one percent level.

■ SD71

S- Jefferson B

Experiments in Supply Chain Contracting

Sponsored: Behavioral Operations Management

Sponsored Session

Chair: Andrew M. Davis, Cornell University, Ithaca, NY, 14853, United States

1 - Managing Multilocation Demand in Supply Chains: An Experimental Investigation

Rihuan Huang, Cornell University, Ithaca, NY, 14853, United States, rh567@cornell.edu, Andrew M. Davis, Douglas J. Thomas

We experimentally investigate managing multilocation demand from a supply chain perspective. Specifically, we consider a two-echelon supply chain consisting of one manufacturer and two retailers. We compare ex ante and ex post demand aggregation strategies. Experimental results show that the ex post strategy when the manufacturer has more pricing power outperforms the ex ante strategy.

2 - Team Decision Making in Operations Management

Jiawei Li, University of Michigan, Ann Arbor, MI, United States

We consider team decision-making in two canonical operations settings: standalone Newsvendor inventory decisions (tactical decision-making) and Newsvendor under information sharing (strategic decision-making). We find that teams perform worse than individuals when making Newsvendor decisions, and exhibit a stronger pull-to-center bias. In the information sharing setting, team retailers are less trustworthy while team suppliers are just as trusting as individual suppliers. We leverage a novel aspect of our experiment: subject teams can text chat to facilitate decision making, and provide evidence for a team-decision making framework that can organize these findings.

3 - Increased Transparency in Procurement: The Role of Peer Effects

Ruth Beer, Indiana University, Kelley School of Business, Bloomington, IN, 47404-5180, United States, ruthbeer@indiana.edu, Daniela Saban, Ignacio Rios

We study the effects of increased transparency in a setting where purchasing decisions are delegated to individual employees as opposed to being centrally managed by an organization. We develop a theoretical model which incorporates peer effects resulting from transparency and we show that there exists a spillover region where an employee is more likely to choose the expensive supplier when he observes that his peer did so. We confirm this finding with a laboratory experiment. We also find that employees whose decisions are observed are less likely to choose the expensive supplier, in line with what the social norm of appropriate behavior prescribes.

4 - The Role of Trust in Aligning Capacity Decisions in Supply Chains

Kyle Hyndman, University of Texas at Dallas, Richardson, TX, 75080, United States, Sara Benetti, Jose Lopez, Florian Federspiel, Santiago Kraiselburd

We study behavior in a series of two-player supply chain game experiments. We focus on the differences in behavior under fixed and random matching. We will measure ex ante, and ex post trust and how it interacts with outcomes and decisions.

■ SD72

S- Columbia

Information Systems VII

Contributed Session

Chair: Dursun Delen, Oklahoma State University, Tulsa, OK, 74106, United States

1 - A Fuzzy Rough Based Algorithm for Automated Decisions in Blockchain Based Supply Chain

Amit Karamchandani, IIM Lucknow, Lucknow, India, fpm17013@iiml.ac.in, Samir K. Srivastava, Akhil Srivastava

Blockchain can enable the availability of all the supply chain data on a single platform. This study aims at developing an algorithm to enable the generation of automated optimized decisions in a blockchain-based supply chain.

2 - Privacy Concerns with Blackchain-based Electonic Health Records

Jingquan Li, Hofstra University, Hempstead, NY, United States, Jingquan.Li@hofstra.edu

Blockchain provides a shared, immutable and transparent history of all the transactions to build electronic health records (EHRs) with trust, accountability and transparency. The very useful features of Blockchain may also raise major privacy issues that may discourage usage. This paper examines major privacy concerns with blackchain-based EHR systems and presents our perspectives on the design of private and trustable blackchain-based EHR systems. This study first discusses how blockchain technology could help data sharing between patients and healthcare providers. It then examines the major privacy concerns. Finally, it proposes a privacy protection architecture for the blockchain.

3 - Development of an Instrument to Measure the Patient Satisfaction for Improving Adherence of Obstructive Sleep Apnea Treatment

Dursun Delen, Oklahoma State University, Tulsa, OK, United States, dursun.delen@okstate.edu, Rupesh Agrawal, Bruce Benjamin

Patient-centric health outcome is the new emphasis to develop targeted treatment for each patient. A homogenous survey instrument is absent, to measure patient satisfaction, experience, expectations, and perceptions. The goal of this study is to conduct exploratory, confirmatory factor analysis to investigate items, construct for survey instrument for patient satisfaction, explicitly for patients with obstructive sleep apnea disorder. The study will lay the foundation for the development of the survey instrument for patient satisfaction, experience, expectations, and perceptions.

4 - Become Friends with Customers: Enterprises Participate in Social Activities in Online Health Communities

Wanxin Qiao, Beijing Institute of Technology, Beijing, China, Zhijun Yan, Junwei Kuang, Fei Peng

The behavior of enterprises participating in social networks is an important operational strategy in marketing and an effective means to increase their stickiness with customers. Most literature has focused on the impacts of the behavior of individual joining social network, but little research has investigated the behavior of enterprises participation in that. Thus, this study examines the relationship between the use of "Friends", a mode with social attributes in online health communities, and customer satisfaction or customer sharing behavior. The results show that enterprises use "Friends" behavior will positively affect customer satisfaction and customer sharing behavior.

■ SD73

S- Boren

Introduction to Financial Engineering

Sponsored: Finance

Sponsored Session

Chair: Agostino Capponi, Columbia University, New York, NY, 10027, United States

Co-Chair: Wendy Swenson Roth, Georgia State University, Atlanta, GA, 30302, United States

1 - Introduction to Financial Engineering

Wendy Swenson Roth, Georgia State University, Atlanta, GA, 30302, United States

The goal of the "Introduction to Financial Engineering" session is to exposure undergraduate students to research opportunities in the area of financial engineering. Students will be presented with an overview of the techniques and research topics that are emerging in the fields of financial engineering, including but not limited to FinTech, economic networks, and market microstructure. The presentation of the topics will be at a fairly high level, and accessible by students with an exposure to the fundamental operations research tools, such as optimization and stochastic systems.

■ SD74

S- Capitol Hill

JFIG Paper Competition Session II

Sponsored: Junior Faculty JFIG

Sponsored Session

Chair: David Goldberg, Cornell University, Ithaca, NY, 14850, United States

Co-Chair: Jennifer K Ryan, University of Nebraska–Lincoln, Dept of Supply Chain Management & Analytics, College of Business, Lincoln, NE, 68588-0491, United States

1 - Distributionally Robust Optimization with Shape Information

Ruiwei Jiang, University of Michigan, Ann Arbor, MI, 48109, United States, Yuanyuan Guo

Incorporating shape information (e.g., unimodality, log-concavity, etc.) into distributionally robust optimization (DRO) models can reduce conservatism. Unfortunately, such incorporation often makes DRO models computationally intractable. This paper investigates a general framework and shows that the corresponding DRO model can be recast as a stochastic program with respect to an unambiguous probability distribution. This facilitates efficient solution algorithms (e.g., sample average approximation) for DRO models with shape information.

2 - Why is Maximum Clique Often Easy in Practice?

Jose Luis Walteros, 1983, Buffalo, NY, United States, Austin Buchanan

To this day, the maximum clique problem remains a computationally challenging problem. Indeed, despite researchers' best efforts, there exist unsolved benchmark instances with one thousand vertices. However, real-life instances with millions of vertices can be solved in a few seconds. Why is this the case? In this paper, we provide a rigorous explanation for this phenomenon based on a graph parameter which we call the clique-core gap. When this graph parameter can be treated as a constant, as is often the case for real-life graphs, the maximum clique problem can be solved in time O(m^1.5).

3 - A Model of Queue-Scalping

Luyi Yang, Johns Hopkins University, Baltimore, MD, 21202, United States, Zhongbin Wang, Shiliang Cui

Recent years have witnessed the rise of queue-scalping in congestion-prone service systems. A queue-scalper has no material interest in the primary service but proactively enters the queue in hopes of selling his spot later. This paper develops a queueing-game-theoretic model of queue-scalping and examines its implications for the service system. Contrary to conventional wisdom, we find that queues with an intermediate demand volume can be most susceptible to scalping, rather than queues with either very small or very large demand volume. This result implies that an effort to mitigate scalping through capacity expansion may only lead to the presence of more scalpers.

■ SD77

S- Fremont

Joint Session OMS/Practice Curated: Contemporary Scheduling

Emerging Topic: Project Management & Scheduling

Emerging Topic Session

Chair: Emrah Cimren, Starbucks, Seattle, WA, 98134, United States

1 - Forecasting Project Delays with Contextual Task Information and Machine Learning

Xiaojia Guo, University College London, International Hall, Lansdowne Terrace, London, WC1N 1AS, United Kingdom, x.guo.11@ucl.ac.uk, Yael Grushka-Cockayne, Bert De Reyck

Forecasting project durations, costs, and resources is a critical process of any project. Inaccurate forecast of these quantities is a major source of risk in project management. We propose a new method of forecasting project durations based on past schedules and actual timelines. We apply text mining and nature language processing techniques to extract characteristics from the name and description of a task. These characteristics, together with those of the task's predecessors, successors and parallel tasks, are used as predictors to forecast the distribution of task durations. We show that our method is more accurate than existing benchmarks in predicting task durations and project durations.

2 - Network Design with Routing Consideration

Emrah Cimren, Starbucks, Seattle, WA, 98134, United States, Joe Caven, Lecoeuche Renaud, Michael Chun

As a result of growing customer demand, companies may need to redesign their distribution network by adding new locations and expanding capacity of distribution centers. In this work, we develop a network design methodology which provides new distribution center locations and facility types in consideration of vehicle routings for efficient transportation activities. The methodology is applied on Starbuck's Consolidated Distribution Center Network.

3 - Detailed Simulation as Means for Scheduling Inventory Movements in a Retail Environment

Cameron Bartok, Starbucks, Seattle, WA, 98134, United States, Thomas Gartner, Renaud Lecoeuche

Today's retail environments must deal with inventory in multiple states; frozen, thawing, fresh etc. To enable business, inventory must be cycled through these states at the right time. This requires balancing the risk of waste given short shelf life of fresh items and the need to have fresh inventory for customers to purchase. In this work we investigate the use of detailed simulation to understand the opportunity and risk of scheduling when and how much inventory to prepare for sale.

4 - Approximation Schemes for Minimizing the Maximum Lateness on a Single Machine with Release Times under Non-availability or Deadline Constraints

Hans Kellerer, Universitat Graz, Graz, Austria, hans.kellerer@uni-graz.at, Imed Kacem

We consider four single-machine scheduling problems with release times, with the aim of minimizing the maximum lateness. In the first problem we have a common deadline for all the jobs. The second problem looks for the Pareto frontier with respect to the two objective functions maximum lateness and makespan. The third problem is associated with a non-availability constraint. In the fourth one, the non-availability interval is related to the operator who is organizing the execution of jobs on the machine. For each of the four problems, we establish the existence of a polynomial time approximation scheme (PTAS).

■ SD78

S- Greenwood

Product and Business Model Innovation

Emerging Topic: New Product Development

Emerging Topic Session

Chair: Niyazi Taneri, National University of Singapore, Singapore, 119245, Singapore

1 - Drivers of Food Waste in Commercial Kitchens: An Empirical Analysis

Varun Karamshetty, INSEAD, Boulevard de Constance, Fontainebleau, 77300, Singapore, Varun.Karamshetty@insead.edu, Elena Belavina

Kitchens are wasting as much on food waste as they make in profits. With an estimated $1 trillion in food being wasted every year, food waste is not only a huge economic loss, but also has a major impact on our environment accounting for nearly 15% of global GHG emissions. We analyze proprietary data, collected using a novel IoT technology based electronic monitoring system, to understand key drivers of food wastage in commercial kitchens. We identify the controllable factors, and quantify the impact of each of them. We then propose changes in their operations that minimize wastage while maintaining their service quality and bottom-line.

2 - Designing Resource Competitions for Research Projects

Wenqi Lian, Singapore Management University, Singapore, wenqilian.2015@pbs.smu.edu.sg, Pascale Crama

University-administered research funds (UARF) at major research universities are an important source of early bridge funding for academic research, often the first step in the journey to secure the necessary government funding. Our model investigates how the UARF's objectives and funding rules affect social welfare outcomes by influencing the novelty and quality of projects being funded by the government. We observe that a UARF funding rule that focuses on novel projects provides the highest social welfare, regardless of the UARF's objective. Finally, we present a non-threshold funding rule that can outperform various threshold-based rules by allocating funds to marginal projects.

3 - Managing Public-private Partnerships for the Development of Drugs for Neglected Diseases

Rongrong Luo, Singapore University of Technology and Design, Singapore, 485999, Singapore, rongrong_luo@mymail.sutd.edu.sg, Shantanu Bhattacharya, Niyazi Taneri, Ying Xu

Although neglected diseases seriously impair people' lives, biopharmaceutical firms lack financial incentives to develop drugs for them. The prevalent solution is to build R&D collaboration between an NGO and the firms. We analyze such a contractual relationship and see how the NGO balances the cost of incentivizing the firms and the social welfare achieved by developing the drug for the neglected disease.

■ SD79

S- Issaquah A

Economic Growth, Environment and Climate

Emerging Topic: Sustainable Growth

Emerging Topic Session

Chair: Yongyang Cai, Ohio State University, Columbus, OH, 43210, United States

1 - Regional Sustainable Economic Development under Risks

Ziqian Gong, The Ohio State University, Columbus, OH, United States, gong.286@osu.edu, Yongyang Cai, Brian Cultice, Ziyu Guo, Shaohui Tang, Yaoping Wang, Jeffrey Bielicki, Alan Randall, Ian Sheldon, Elena Irwin

We develop a Dynamic Regional Food, Energy, Water Systems (DRFEWS) model to analyze the environmental sustainability and individual well-being resulting from shifts in complex economic and environmental systems. Our DRFEWS model uses a dynamic general equilibrium framework to represent the interactions between local, regional, national, and global systems across time and space as well as sectors including households, farming, manufacturing, food, energy, and ecosystem. We apply our model to evaluate the sustainability of Great Lakes (GL) regional economic practices, and then help decision-makers maximize the potential of the GL economy and environment to benefit its citizens.

2 - Assessing the Economic and Environmental Efficiency of the Ukrainian Power Generation Sector

Javier Inon, World Bank Group, Washington DC, CO, United States, javier.inon@gmail.com, Jevgenijs Steinbuks, Debabrata Chattopadhyay

This study seeks to assess the efficiency of the Ukrainian power generation under physical, regulatory and environmental constraints. Using a novel dataset on electricity generation for each utility-scale power plant from 2012 to 2018, we optimize the generators' dispatch accounting for zonal transmissions caps and fuel, import and operational limits. The cost-efficiency gap is calculated between the observed allocations and prices to the least-cost solutions. Sensitivity and econometric analyses are performed to account for uncertainties in transmission constraints, fuel supply limits and environmental mandates, and determining key factors affecting the calculated efficiency gap.

3 - Optimal Timber Management Decisions in the Face of Future Uncertainties

Alla Golub, Purdue University, West Lafayette, IN, 95032, United States, golub@purdue.edu, Brent Sohngen, Yongyang Cai, Thomas Hertel, John Kim

The goal of this study is to examine the impacts of uncertainty in future climate, income and population, as portrayed in the IPCC's Shared Socio-Economic Pathways, on optimal timer management decisions. The analysis is based on a dynamic forward looking model of global land use with biome specific competition for land, representation of timber sector, and climate impacts. A min-max-regret analysis is conducted to determine a robust path of timber management investments that factors in key uncertainties. The results suggest that, while climate change can have important consequences for forests, economic growth has the strongest impact on forested ecosystems in the future.

4 - Climate Policy with Carbon Removal and Storage in a Dynamic Stochastic Economy

Yongyang Cai, Ohio State University, Columbus, OH, 43210, United States, cai.619@osu.edu, Kenneth Judd

We build a dynamic stochastic integrated model of the climate and economy to incorporate elements such as carbon removal and storage, economic risks, recursive preference, and climate target constraints (e.g., the global average atmospheric temperature increase does not exceed 2 or 1.5 Celsius). We solve it numerically using parallel value function iteration for the high-dimensional dynamic stochastic programming problem. We find that the climate target constraints significantly increase the social cost of carbon (SCC), and the technology improvement in carbon removal and storage can significantly reduce the SCC.

■ SD80

S- Issaquah B

Innovation and Entrepreneurial Operations

Emerging Topic: Technology, Innovation Management & Entrepreneurship

Emerging Topic Session

Chair: Karthik Ramachandran, Georgia Institute of Technology, Atlanta, GA, 30308, United States

1 - Inventory, Speculators and Initial Coin Offerings

Rowena J. Gan, The Wharton School, Philadelphia, PA, 19103, United States, ganj@wharton.upenn.edu, Gerry Tsoukalas, Serguei Netessine

Initial Coin Offerings (ICOs) are an emerging form of fundraising for Blockchain-based startups. We propose a simple model of matching supply with demand with ICOs by companies involved in production of physical products. We examine how ICOs should be designed in the presence of product demand uncertainty, make predictions on ICO failure, and discuss the implications on firm operational decisions and profits.

2 - Dueling Innovation Contests

Konstantinos Stouras, UCD Smurfit, Stillorgan, Ireland, konstantinos.stouras@ucd.ie, Sanjiv Erat, Casey Lichtendahl

In a crowdsourcing platform, firms design competing innovation contests and solvers self-select which contest to exert effort into. We study equilibria among competing budget allocations. We show that there is a unique dominant strategy for each firm to reward multiple identical rewards. In contrast, when firms' objectives are sufficiently close to ideation contests, a single first reward is the unique equilibrium allocation. Our theory predicts that observed variation in reward provision can be explained by different objectives of competing firms.

3 - Sequential Product Development and Introduction by Cash-constrained Start-ups

Sreekumar R. Bhaskaran, Southern Methodist University, Cox School of Business, Dallas, TX, 75275, United States, Sinan Erzurumlu, Karthik Ramachandran

For startups, introduction of an on-hand product can generate additional funds to support the development of an advanced product. However, the lower performance of the on-hand product can negatively impact the perceptionof the firm's future products—i.e., cannibalize the payoffs of the advanced product—and lower future profitability. We study this trade-off between revenues that an on-hand product generates for R&D funding and the cannibalization effect it has on future products. We characterize the optimal introduction timing of the on-hand product as a function of the financial resource constraints, the interdependence between these sequential products and the cost of development.

4 - The Learning-financing Tradeoff At Lean Startups

Onesun Steve Yoo, University College London, School of Management, London, E14 5AB, United Kingdom, onesun.yoo@ucl.ac.uk, K. Sudhir

The lean startup methodology advocates an iterative and adaptive product development and testing approach that maximizes the startup's likelihood of market success. However, the entrepreneur faces an important tradeoff between product development and testing choices that optimizes learning for the startup's market success against observable signals for investors who decide on whether to finance the startup and the terms of financing. We characterize the learning-financing tradeoff and the extent of its effects in a startup's product development choices.

■ SD81

S- Kirkland

Forestry IV: Models and Methods for Forest Planning under Risk

Sponsored: Energy, Natural Res & the Environment/Forestry

Sponsored Session

Chair: Andres P Weintraub, Universidad de Chile, Santiago, Chile

Co-Chair: Cristóbal Pais, UC Berkeley, Berkeley, CA, United States

1 - Downstream Protection Value: A Firesmart Fuel Management Decision Support System for Reducing Landscape Wildfire Risk

Cristóbal Pais, M. Sc, UC Berkeley, Berkeley, CA, United States, j.garcia@ctfc.es

Please check the mobile app for this abstract.

2 - A Simulation Based Heuristic Approach to Support Decision to Support Decisions in Forest Fires Fuel Management

Andrés P. Weintraub, Professor, Universidad de Chile, Santiago de Chile, Chile

How to incorporate protection of valuable forest areas from future firesinto management plans is a complex problem, in particular given the spatial andhigh uncertainty characteristics of fires. We make use of a stochastic firespread simulator to evaluate different harvesting strategies throughcarrying out a high number of simulations.

3 - Cell2fire: A New Stochastic Cell-based Fire Growth Model for Forest Management

Jaime Adrián Carrasco Barra, PhD Student, Universidad de Chile, Santiago de Chile, Chile

Cell2Fire is a new cell-based forest and wildland landscape fire growth simulator. The fire environment is characterized by partitioning the landscape into a large number of homogeneous cells and specifying the fuel, weather, fuel moisture and topography attributes of each cell. Fire spread within each cell is assumed to be elliptical and governed by spread rates predicted by different fuel models. In particular, the BehavePlus Fire Modeling, Canadian Forest Fire Behavior Prediction, and Kitral Chilean Systems are included in Cell2Fire. We validated Cell2Fire by using it to predict the growth of real fires and compared our predictions with those produced by existing state-of-the-art simulators.

4 - A Parallel Progressive Hedging Algorithm for Stochastic Harvest Scheduling under Climate Change

Martin B. Bagaram, PhD Student, University of Washington, Seattle, WA, United States, martb@uw.edu, Sandor F. Toth, Weikko S. Jaross, Andres P. Weintraub

To account for climate change, in forest harvest scheduling, we discretize the potential distribution of forest growth under different climate scenarios and solve the resulting stochastic mixed integer program. Increasing the number of scenarios allows to better approximate the entire probability space of future forest growth but at the computational expense. We propose to solve in parallel the scenario-based sub-problems using parallel computing. We fix the variables (starting from the root-node) upon satisfaction of their relevant non-anticpativity constraints. Once all variables from a node are fixed, the model can be separated into sub-problems that are recursively solvable in parallel

■ SD82

S- Leschi

Joint Session ENRE/Elec/Practice Curated: Computational Frontier in Power Systems

Sponsored: Energy, Natural Res & the Environment/Electricity

Sponsored Session

Chair: Feng Qiu, Argonne National Laboratory, Lemont, IL, 60439, United States

Co-Chair: Alinson Xavier, Argonne National Laboratory, Argonne, IL, 60439, United States

1 - New Formulation of Transmission Constraints for Decentralized Power Systems Optimization

Alinson Santos Xavier, Argonne National Laboratory, Argonne, IL, 60439, United States, axavier@anl.gov, Feng Qiu, Santanu Subhas Dey

The DC power flow formulations most commonly used in the industry, based on injection shift factors, have dense and unstructured constraints, which makes them unsuitable for decentralized studies. In this work, we propose a new DC power flow formulation which has a decomposable block-diagonal structure, scales well for large systems, and can handle N-1 security requirements. The formulation can also be used to determine optimal energy exchange prices between neighboring zones. Benchmarks on Multi-Zonal Security-Constrained Unit Commitment show that it can reliably solve instances with up to 6,515 buses, with no convergence or numerical issues.

2 - Spatial and Topological Interdiction for Transmission Systems

Russell Bent, Los Alamos National Laboratory, Los Alamos, NM, 87545, United States, Kaarthik Sundar, Sidhant Misra, Feng Pan

This talk models two new classes of N-k attacks in power transmission system: (i) Spatial N-k attacks where the attack is constrained to be within a specified distance of a bus chosen by an attacker and (ii) Topological N-k attacks where the attack is constrained to connected components. Each of these problems is formulated as bilevel, max-min optimization problems algorithms to solve these formulations will be presented. Detailed case studies analyzing the behavior of these interdiction problems and comparing them to the traditional worst-case N-k interdiction problem will also also presented.

3 - HIPPO – Numerical Experiments for Solving Unit Commitment

Feng Pan, Pacific Northwest National Laboratory, Richland, WA, 99352, United States, Yonghong Chen, Jesse Holzer, Ed Rothberg, Arun Veeramany

HIPPO is a software library developed to solve security constrained unit commitment (SCUC) problems. The size of SCUC can be large for ISO-size day-ahead market and SCUC model can have a wide-range performance on different market cases. In this talk, we will discuss the numerical experimental results from solving SCUC on MISO cases.

4 - Machine Learning for Improving Power System Optimization Performance

Feng Qiu, Argonne National Laboratory, Lemont, IL, 60439, United States, Alinson Santos Xavier, Shabbir Ahmed, Xiaoyi Gu, Santanu S. Dey

Machine learning has been used in various areas in energy sector, e.g., forecasting and detection. In this talk, we focus on using machine learning techniques to improve the computational performance of a number of fundamental mixed-integer programming optimization problems in power systems. Machine learning is used to extract information from historical instances (e.g., input data, solutions, solver information) to improve the computational performance of MILP solvers when solving similar instances in the future. Computational results show that the proposed machine learning approaches can effectively improve the performance.

■ SD83

S- Medina

Enhancing Renewable Energy Integration through Optimization Techniques

Sponsored: Energy, Natural Res & the Environment/Electricity

Sponsored Session

Chair: Neng Fan, University of Arizona, Tucson, AZ, 85721, United States

Co-Chair: Jose Ruiz Duarte, University of Arizona, Tucson, AZ, 85721, United States

1 - Operations Management for a Vertical Farm with Onsite Renewable Energy Integration and Demand Response

Jose Luis Ruiz Duarte, University of Arizona, Tucson, AZ, 85721, United States, jlruizduarte@email.arizona.edu, Neng Fan

Food security is one of the main issues addressed by international community. Controlled environment agriculture increases the productivity of food systems at the cost of being highly energy intensive due to the control mechanisms to simulate an ideal environment for crops. In this presentation, the development of an optimization model for the energy-related operations of a controlled environment greenhouse with onsite energy storage systems and renewable energy sources with uncertain power output and operating under demand-side management policies is shown. A sensitivity analysis is performed under different scenarios and growing policies.

2 - A Co-optimization Scheme of Distributed Joint Market with Microgrids

Yiwei Wu, University of Houston, Houston, TX, 77004, United States, ywu41@uh.edu, Gino J. Lim, Jian Shi

The microgrid (MG) is becoming the most promising platform to incorporate distributed energy resources. However, the potential for microgrids to provide ancillary services (AS) to support the distribution system (DS) operation has not been well explored. Besides, the interaction procedures between MGs and DS become more complicated with both power delivery and AS. In this work, we proposed a decentralized joint DS market structure where the MGs can conduct power delivery and AS scheduling. The problem is formulated as a bi-level programming model where the upper level is a DS management problem and the lower level presents MG optimal scheduling problem and solved using an efficient algorithm.

3 - Behavior of Storage Capacities in Response to Market Prices

Mehrdad Pirnia, University of Waterloo, Waterloo, ON, N2L3G1, Canada, mpirnia@uwaterloo.ca, John David Fuller, Hassan Shavandi

We present an analytical research to study the behavior of electric storage capacities in response to electricity market prices, when renewable generation with and without uncertainty is integrated into the grid. Our study considers both deterministic and stochastic models when the storage capacity participates in reserve market and when it operates as only an energy market. To model the stochastic models we use chance constraints. We use the findings of this research to estimate the service life of batteries based on their cycles.

4 - N-1-1 Contingency-Constrained Unit Commitment with Renewable Integration and Corrective Actions

Daniel A. Zuniga Vazquez, University of Arizona, Tucson, AZ, 85721, United States, danielzunigav@email.arizona.edu, Jose L. Ruiz Duarte, Neng Fan, Feng Qiu, Jianhui Wang

Achieving an N-1-1 reliable power system is crucial. The complexity is increased for the unit commitment problem when contemplating renewable energies, due to their intermittent behavior. This research presents a power system unit commitment problem attaining the N-1-1 reliability standards defined by NERC with corrective actions, as well as operations compliance check on economic dispatch, power flows under contingency states, and worst case renewable energy generation. For an efficient solution, a variation of the nested Column-and-Constraint-Generation (C&CG) algorithm is presented. The model and algorithm are evaluated on modified versions of several IEEE test systems.

■ SD84

S- Ravenna A

Optimization in Energy and Power Grids

Sponsored: Energy, Natural Res & the Environment/Energy

Sponsored Session

Chair: Shenyinying (Ruby) Tu, Northwestern University

1 - A Two-Stage Decomposition Approach for AC Optimal Power Flow

Shenyinying Tu, Northwestern University, Hampton Pkwy, Evanston, IL, 60201, United States, Andreas Waechter, Ermin Wei

This paper proposes a decomposition approach to solve ACOPF problems. The power network is decomposed into a master network and a set of subnetworks. We formulate the problem as a two-stage optimization problem and require only a small amount of communication between the master network and subnetworks. The key contribution is a novel smoothing technique that renders the response of a subnetwork differentiable with respect to the input from the master problem. Speedup can be obtained by processing the subnetworks in parallel. Numerical results show favorable convergence results and illustrate the scalability of the algorithm.

2 - Finding Solutions to Security-constrained ACOPF Problems

Daniel Bienstock, Columbia University, New York, NY, United States, dano@columbia.edu

We discuss methodologies used to address the security-constrained ACOPF problem in the recent GO competition. Joint work with R. Waltz, S. Mourait and J. Nocedal.

3 - Optimal Power Flow with Sequential Convex Restriction - Identifying a Feasible Path

Line Roald, University of Wisconsin-Madison, Madison, WI, 87544, United States

Due to the non-convexity of the AC optimal power flow, it is unclear whether there exists a sequence of control actions which can drive the system from our current to the new, optimal operating point without violating any operational constraints. Here, we describe a method to identify such a feasible path by solving a sequence of convex quadratic programs, where each program corresponds to a convex inner approximation of the AC feasible region. Due to the properties of convex sets, there is a guaranteed feasible path between the operating points identified in each iteration. Extensive numerical studies on IEEE test cases show that the method arrives at a high-quality solution in few iterations.

4 - Grid-Aware versus Grid-Agnostic Distribution System Control: A Method for Certifying Engineering Constraint Satisfaction

Daniel K. Molzahn, Assistant Professor, Georgia Institute of Technology, Atlanta, GA, 60605, United States, molzahn@gatech.edu, Line Roald

Distributed energy resource (DER) controllers may be grid-agnostic or grid-aware, depending on whether distribution network constraints are considered. Grid-agnostic controllers do not need network models or system measurements, but may cause dangerous constraint violations. We consider the potential impacts of DER controllers with respect to network constraint violations. Specifically, we describe an optimization-based method that certifies when any grid-agnostic controller can be applied without concern regarding network constraint violations, or, conversely, when grid-aware control may be needed to maintain distribution grid security.

■ SD85

S- Ravenna B

Advanced Analytics for Local Energy Markets and Aggregator Business Models

Sponsored: Energy, Natural Res & the Environment/Energy

Sponsored Session

Chair: Anthony Papavasiliou, CORE, UCL, Voie du Roman Pays 34, L1.03.01, Office b.114, Louvain la Neuve, 1348, Belgium

Co-Chair: Yuting Mou, Universite Catholique de Louvain

1 - A Bi-Level Optimization Formulation of Multilevel Demand Subscription Pricing

Yuting Mou, Universite Catholique de Louvain, Louvain, Belgium, Anthony Papavasiliou, Philippe Chevalier

In this study, we revisit multilevel demand subscription pricing (MDSP) for electric power, in which a price plan to assign different reliability combined with duration for a slice of power is offered. We formulate the menu design as a Stackelberg game where an aggregator moves first with a menu, and residential consumers react by selecting menu options. The Stackelberg game is modelled as a bi-level optimization problem, and then reformulated as an MIP. Using our approach, we can integrate the menu design problem into a day-ahead market model and mobilize residential flexibility.

2 - Private Versus Public Information and Mechanism Design for Aggregating Customers in the Electricity System

Alberto J. Lamadrid, Lehigh University, Bethlehem, PA, 18015-3120, United States, Tim Mount

We present a market structure for hierarchical exchanges between an electric transmission system operator and independent aggregators controlling distributed storage, in the form of deferrable demand. The objective of these aggregators is to minimize the expected payments for electric energy, subject to meeting the energy needs of their customers, while submitting bids into the wholesale market as an interface with the system operator. This structure represents an alternative to, e.g., extending the logic of nodal pricing to individual customers or adding markets for new products such as VARs.

3 - Negotiation Mechanisms for Local Energy Markets

Thomas Morstyn, University of Oxford, Oxford, OX1 1HG, United Kingdom

Local energy markets offer the new opportunity to incentivise coordination between owners of distributed energy resources, so that their flexibility can be integrated into power system operations. Recently proposed mechanisms for negotiating transactions in local energy markets are presented, including profit sharing based on cooperative game theory; deferred acceptance from matching market theory; distributed optimisation; and unidirectional locational marginal pricing. These mechanisms are compared in terms of trade-offs offered for market objectives including economic efficiency, game theoretic stability, computational burden and addressing network constraints.

4 - Operate a Local Energy Market (LEM) Based on Market Clearing Algorithms – N-SIDE and Centrica Present their Pioneering Platform

Damien Denayer, N-SIDE, Louvain, Belgium, Olivier Devolder

To help system operators (SO), N-SIDE and Centrica are developing an innovative Local Energy Market (LEM) platform. Its purpose is to unlock the potential of flexibility at low voltage level and to provide alternatives to grid reinforcement or long term contracts. It includes a market clearing algorithm matching bids and offers, ensuring transparent solutions, maximizing the gains for the flexibility owners and minimizing the costs for SO. The market is being tested in a project in the UK. N-SIDE and Centrica will demonstrate the different features of the LEM, its benefits and the first results.

■ SD86

S- Ravenna C

Regional Modeling of Energy Systems

Sponsored: Energy, Natural Res & the Environment/Energy

Sponsored Session

Chair: Gokul Iyer, Pacific Northwest National Laboratory, College Park, MD, 20740, United States

Co-Chair: Felipe A Feijoo, Chile

Co-Chair: Zarrar Khan, Pacific Northwest National Laboratory, College Park, MD, 20740, United States

1 - Climate Variability Impacts on US Power System Capacity and Operations

Gokul Iyer, Pacific Northwest National Laboratory, College Park, MD, 20740, United States, gokul.iyer@pnnl.gov, Zarrar Khan, Pralit Patel, Marshall Wise, Mohamad Hejazi, Sonny Kim

Electricity demand is expected to grow over the coming decades creating a need for long-term power sector planning to ensure an adequate and reliable power system capable of adapting to changes in demand profiles within a multi-sectoral framework. Existing power sector models capture the complexities of electricity supply and demand but often ignore the broader system. In contrast, multi-sector human-earth system models capture complex relationships across sectors and systems but represent power sector dynamics at fairly aggregate levels. In this study we enhance GCAM-USA, an existing multi-sector model to capture sub-annual electricity demand dynamics in response to changing temperatures.

2 - Energy Transitions for Reaching Climate Targets: The Case of 1.5c Energy-water-food Nexus in Latin America

Felipe A. Feijoo, Pontificia Universidad Catolica de Valparaiso, Av. Brasil 2241, Office 6-8, Valparaiso, Chile, felipe.feijoo@pucv.cl, Andrea Arriet

We study the energy, food, water nexus in Latin American countries under scenarios consistent with the Paris agreement of making efforts to keep global warming to 1.5C by the end of the century. For this research, we developed and used a detailed version of the Global Change Assessment Model (GCAM) develop for Latin America. The benefits of using a detailed version of GCAM (GCAM-LAC) are also discussed.

3 - Regional Energy Deployment System 2.0 – An Open Access Capacity Expansion Model

Maxwell Brown, National Renewable Energy Laboratory, Golden, CO, United States

This presentation focuses on the re-development of the Regional Energy Deployment System (ReEDS 2.0), a detailed capacity expansion model of the continental US. Specific topics addressed are the motivation behind and challenges in redeveloping the model as well as considerations for future development.

4 - Electrification Scenarios for New York State's Low Carbon Energy Future

Delavane Diaz, Electric Power Research Institute, Washington, DC, 20005, United States

This paper describes an enhanced version of EPRI's innovative US-REGEN energy-sector model to capture the integrated nature of New York's electric and non-electric energy systems with high structural, temporal, and spatial resolution. We develop and compare a range of policy and technology scenarios to evaluate the potential role of electric technologies to meet energy needs, and resulting impacts on modeled energy system and environmental outcomes through 2050 in New York State.

5 - Achieving Climate-land-energy-water Sustainable Development Goals in the Indus Basin and the Role of Cross-border Cooperation

Adriano Vinca, International Institute for Applied Systems Analysis, Laxenburg, Austria
Adriano Vinca, University of Victoria, Victoria, BC, Canada, Simon Parkinson, Ansir Ilyas

The Indus Basin, a highly densely irrigated area home to about 300-million people, has expected growing demands for water, energy and food in the coming decades. With no abundant surface water left in the basin and accelerating use of groundwater, long-term strategic and integrated management of water and its interlinked sectors (water-energy-land) is fundamental for the sustainable development of the region. We show a scenario-based analysis using numerical models (The Nexus Solution Tool) where we link local issues and policies to the Sustainable Development Goals, showing synergies and conflicts among different objectives and the value of international cooperation to achieve such goals.

Monday, 8:00AM - 9:30AM

■ MA01

CC- Room 201

Joint Session DM/Practice Curated: Data Analytics for Retailers

Sponsored: Data Mining

Sponsored Session

Chair: Chloe Glaeser

1 - The Value of Pop-up Stores on Retailing Platforms: Evidence from a Field Experiment with Alibaba

Dennis Zhang, Washington University in St Louis, St Louis, MO, 63130, United States, denniszhang@wustl.edu, Hengchen Dai, Lingxiu Dong

Omni-channel retailing has become an essential strategy in modern-age retailing. We study the value of short-lived and experiential-oriented pop-up stores, a popular type of omni-channel retail strategy, on both retailers that participate in pop-up store events and retailing platforms that host these retailers. We conducted a large-scale randomized field experiment with Alibaba Group involving approximately 800,000 customers and used advanced Wi-Fi technology to track every customer's visit to a pop-up store—a missing component from past research that commonly relies on point-of-sales data.

2 - How to Find Your Most Valuable Service Outlets: Measuring Influence Using Network Analysis

Qiuping Yu, Georgia Institute of Technology, Atlanta, GA, 47405-1701, United States, Shawn Mankad, Masha Shunko

Consider a network of stores operating under the same brand, for example, a chain of coffee shops (Starbucks). Improving quality and increasing sales at one store may have different impact on the other stores: from negative impact as a result of potential cannibalization, to positive impact from improved brand reputation and knowledge spillover. In this paper, we propose a methodology to causally identify the network effects that stores have on each other and the total influence of each store on the entire network at a large scale. By applying our method to a large dataset from a major national restaurant chain in the US, we provide insights in effectively managing the network of the brand.

3 - Personalizing Retail Promotions Through a Dag-based Representation of Customer Preferences

Srikanth Jagabathula, NYU Stern School of Business, New York, NY, 10012, United States, sjagabat@stern.nyu.edu, Dmitry Mitrofanov, Gustavo J. Vulcano

We propose a new method to personalize promotions in the retail setting. Our method relies on a new representation of customer preferences in the form of a directed graph. A directed edge A -> B from brand A to brand B in the graph indicates that the customer strongly prefers brand A over brand B, and this preference remains stable over time. We assume that these preferences are acyclic, so our representation will become a directed acyclic graph (DAG). We propose techniques using which a retailer can infer the DAG representation of each customer from observed purchase transactions. We demonstrate the efficacy of our approach on data from a collection of grocery retailers.

4 - Predictive and Prescriptive Analytics for Location Selection of Add-on Retail Products

Teng Huang, University of Connecticut, Storrs, CT, United States, teng.huang@uconn.edu, David Bergman, Ram Gopal

We study an analytical approach to selecting expansion locations for retailers selling add-on products. In our context, both base and add-on products could be subject to spatial autocorrelation. Using data from an industrial partner, we build predictive models for understanding the derived demand of the add-on product and establish an optimization framework for automating expansion decisions to maximize expected sales. Spatial autocorrelation and the complexity of the predictive model impact the complexity and the structure of the prescriptive optimization model. Using the optimization framework can result in substantial increases in expected sales over baseline policies.

■ MA02

CC- Room 202

Data Analytics in Developing Quality Management Theory

Sponsored: Data Mining

Sponsored Session

Chair: Richard Peng

Co-Chair: Heng Xie, University of North Texas - College of Business, Denton, TX, 76203-5017, United States

1 - Multiple Methods Analysis for Quality Management Theory Development

Heng (John) Xie, University of North Texas, 1155 Union Circle #311277, 304C, Denton, TX, 76203-5017, United States, Heng.Xie@unt.edu, Xianghui (Richard) Peng, Victor R. Prybutok

This study uses meta-analysis and text mining to compare the gaps between academic literature and industry practice in quality management. We analyze the findings from the literature by using meta-analysis. We utilize confirmatory semantic analysis to examine the Baldrige winners. The results reassess the relationship between quality management practices and performance. This study contributes to quality management theory development.

2 - Investigating the Dynamics of Quality Management Theory Evolution Through Text Analytics

Benjamin T. George, Assistant Professor of Business Analytics, University of South Dakota, Sioux Falls, SD, 57106, United States, Bartlomiej Hanus, Rebecca Scott

Quality Management Theory (QMT) is an ever-evolving paradigm driven by changes in both technology and emerging applications for quality. The chief chronicler of this growth is the academic journals within the field. The goal of this study is to examine whether the underlying concepts of quality theory are presented differently through Application-driven and Technical-driven quality publications. We scraped data from respective abstracts of two competing academic quality-focused journals. Text mining techniques are then applied to investigate the underlying characteristics to determine similarities and differences.

3 - A Meta-analysis of Technology Acceptance in Healthcare

Xinyu Wei, University of North Texas, Denton, TX, 76201, United States, xinyu.wei@unt.edu, Victor R. Prybutok, Xianghui (Richard) Peng

The study of healthcare technology acceptance from a consumer's perspective generates increasing interest in both academia and industry. In the current study, we synthesize relevant findings from previous empirical studies to extend and refine the existing technology acceptance theories in healthcare context using meta-analysis techniques. Insights for practitioners and contributions to academia, especially quality management, are discussed.

■ MA03

CC- Room 203

Data Mining in Power Systems

Sponsored: Data Mining

Sponsored Session

Chair: Feng Qiu

1 - Mining Utility Data for Enhancing Distribution Grid Observability and Resilience

Zhaoyu Wang, Iowa State University, Ames, IA, 50011, United States, wzy@iastate.edu

This talk will present our research on enhancing power distribution grid observability and resilience using real utility data and machine learning techniques. We have archived a large amount of smart meter, PMU and SCADA data and associated grid circuit models from collaborating utilities. By leveraging the smart meter data, we can infer hourly consumption patterns of unobservable customers using only their monthly billing information. In addition, we have used multi-year data from outage management systems to model distribution grid resilience curves and characterize resilience features.

2 - An Online Mechanism Design to Elicit Multi-Dimensional Flexibilities from Electric Vehicles

Bo Sun, the Hong Kong University of Science and Technology, Hong Kong, Hong Kong, bsunaa@connect.ust.hk, Xiaoqi Tan, Danny Tsang

Electric vehicles (EVs) have been well-recognized as a deferrable load in demand-side management programs. To better integrate an increasing number of EVs into power systems reliably and economically, we identify and exploit two novel and promising flexibilities, namely, energy-flexibility and deadline flexibility, beyond the deferrable properties of EVs. We have designed a priced-based online mechanism to elicit those multi-dimensional flexibilities from EVs to maximize the social welfare. Our proposed mechanism is proved to have a bounded competitive ratio theoretically, and can achieve competitive empirical results in numerical tests based on real-world traces of taxi vehicles.

3 - Methods for Behind-the-Meter Solar Estimation and Forecasting

Yingchen Zhang, NREL

Distributed photovoltaic (PV) generation often occurs “behind the meter”: a distribution grid operator can only observe the aggregate load, the sum of the true, masked load and the PV generation. This lack of observability poses a challenge to distribution grid management strategies, which typically require real-time or near-future disaggregated estimates of load and PV generation. In this presentation I will discuss use of local solar irradiance measurements to estimate and forecast solar power, to disaggregate the summed PV generation and true load signals.

4 - Classification of Imbalanced Structured Data Using Convolutional Neural Network

Yoon Sang Lee, Columbus State University, Columbus, GA, United States, yslee211@gmail.com

This study proposed a technique mitigating imbalance class problem of structured data. The technique proposed in the study combines the label encoding, discretization, the conversion of instance to image files, and the use of CNN for the classification of the image files. For the performance evaluation, we used five data sets from UCI repository. For each data set, we created different data sets encoded by different preprocessing steps respectively, and each created data set is classified by five different classifiers. The result of the experiment shows that the CNN with the discretization and label encoding provides the best performance in all combinations of preprocessing steps and classifiers.

■ MA04

CC- Room 204

Data Mining for Railroad Safety, Maintenance and Management

Sponsored: Data Mining

Sponsored Session

Chair: Trefor Williams, PhD, Rutgers University, Piscataway, NJ, United States

Co-Chair: John F. Betak, Collaborative Solutions LLC, Albuquerque, NM, 87122, United States

1 - Statistical Estimation on Infrastructure Networks

Robert Bassett, Navel Postgraduate School, Monterey, CA, United States

This talk will introduce new developments in statistical estimation on networks. We will focus on Fused Density Estimation, a technique for constructing density estimates from observations which occur along the edges of a network. We will address computational challenges and provide theoretical support for the use of the Fused Density Estimation. Lastly, we review applications of the technique to infrastructure networks, demonstrating the efficacy of the technique with a number of real-world examples.

2 - SME Miner: Utilizing Specialized Corpus Choices by Text Mining Application

Christie Nelson, Rutgers University, Princeton, NJ, 08540, United States, cnelson@dimacs.rutgers.edu, Trefor Williams, John F. Betak, Alex Nguyen, Kartheek Reddy Mondeddu, Ivan Mera, Jon McGuire

A tool, SME Miner, has been created to analyze free-text fields in a somewhat novel manner: extracting subject matter expert (SME) identified keywords and utilizing the count of these keywords per instance as an additional attribute in traditional machine learning methods. SME Miner automates the process of extracting SME-identified dictionary words from free-text, bins them by category, and creates a count-per-instance. We will show a proof-of-concept utilizing a railroad company's maintenance log along with how one might do a second application utilizing a government agency's background check data.

3 - Identifying Themes in British and American Railroad Accident Reports Using LDA

Trefor Williams, Rutgers University, Piscataway, NJ, 08540, United States, tpw@rci.rutgers.edu

Topic modeling, a type of text mining was used to analyze themes in railroad accident investigations conducted by the Railroad Accident Investigation Board (RAIB) in the United Kingdom. Latent Dirichlet Allocation was used to automatically generate 15 topics. The major themes found from the RAIB reports included accidents involving maintenance crews and track possession, accidents involving train doors, and accidents involving level crossings. A comparison of the RAIB topics with those found from the accident reports of the National Transportation Safety Board in the United States showed that common accident themes were level crossing accidents, bridges, switching, and signals.

■ MA05

CC- Room 205

Recent Trends in Machine Learning and Optimization

Sponsored: Data Mining

Sponsored Session

Chair: Yan Xu

1 - Wasserstein Distributionally Robust Inverse Multiobjective Optimization

Bo Zeng, University of Pittsburgh, Benedum Hall, Pittsburgh, PA, 15260, United States, bzeng@pitt.edu, Chaosheng Dong

We present a distributionally robust approach to inverse multiobjective optimization. Specifically, we study the problem of learning the objective functions or constraints of a multiobjective decision making model, based on a set of observed decisions. We use the Wasserstein metric to construct the uncertainty set centered at the empirical distribution of these decisions. We show that this framework has statistical performance guarantees. Also, an algorithm is developed to solve the resulting formulation and prove its finite convergence. Numerical results demonstrate the performance of the distributionally robust approach to inverse multiobjective optimization.

2 - Quasi-Newton Trust-Region Methods for Machine Learning Problems

Riadh Omheni, SAS Institute, Cary, NC, United States, Jennifer Erway, Joshua Griffin, Roummel Marcia

Machine learning (ML) problems are often posed as highly nonlinear and nonconvex unconstrained optimization problems. Methods for solving ML problems based on stochastic gradient descent generally requires fine-tuning many hyper-parameters. In this talk we present alternative approaches for solving ML problems based on a quasi-Newton trust-region framework. Numerical experiments showing the efficiency of this approach will be presented.

3 - Improving Chronic Disease Forecasting with Synthetically Augmented Datasets

Matthew Baucum, University of Tennessee-Knoxville, Knoxville, TN, United States, Anahita Khojandi, Robeto Fernandez

Deep learning is a powerful tool for healthcare analytics, but because of the paucity of longitudinal data, it may not show great performance when used to forecast patient disease progression with small sample sizes. In this study, we build two disease forecasting models with a small dataset of Alzheimer's patients (a neural network and recurrent neural network). We then use hidden Markov models and variational autoencoders to augment the training data with synthetic patient profiles. Synthetic data from the variational autoencoder significantly improved the forecasting model's accuracy; we discuss insights from the models and implications for future work.

4 - Constrained Multi-Objective Optimization for Automated Machine Learning

Yan Xu, SAS Institute, Inc., Cary, NC, 27519, United States, yan.xu@sas.com

Automated machine learning has gained a lot of attention recently. Building and selecting the right machine learning models is often a multi-objective optimization problem. General purpose machine learning software that simultaneously supports multiple objectives and constraints is scant, though the potential benefits are great. In this work, we present a framework called Autotune that effectively handles multiple objectives and constraints that arise in machine learning problems.

■ MA06

CC- Room 209

Debiasing Decision Making – Ethical Data Mining and Eliminating Algorithmic Bias

Sponsored: Data Mining

Sponsored Session

Chair: Heidi Livingston Eisips, MBA, San Jose State University, San Jose, CA, United States

1 - Debiasing Decision Making – Ethical Data Mining and Eliminating Algorithmic Bias

Heidi L. Eisips, Adjunct Faculty, San Jose State University, San Jose, CA, 95111, United States, heidi.eisips@sjsu.edu

Data Mining and Data Analytics have provided modern society with fantastic benefits and productivity gains. Data is everywhere, and some posit that data is the new currency of the digital economy. And yet we know that human biases and machine-learned biases can have enormous costs: negative social impacts, financial losses, and sometimes even catastrophic loss of life. This panel will explore ways that we can develop the social awareness, engineering know-how, business processes, and legal instruments necessary to better reap the benefits of big data while harnessing an ethical framework and mitigating the risks introduced by human and algorithmic bias.

Panelist

- Nathan R. Colaner, Seattle University, Seattle, WA, United States
- Jitendra Mudhol, CollaMeta, San Francisco, CA, 94807, United States
- Tracy Kosa, Seattle University, Seattle, WA, United States
- Bill Franks, International Institute for Analytics, Portland, OR, 30097, United States
- Brian Wright, GWU, McLean, VA, 22101, United States

■ MA07

CC- Room 210

Financial Statistics and Applications

Sponsored: Finance

Sponsored Session

Chair: Markus Pelger, Stanford University, Stanford, CA, 94305, United States

1 - Crowding and Liquidity Provision in Factor Investing

Victor DeMiguel, London Business School, Management Science and Operations, Regents Park, London, NW1 4SA, United Kingdom, avmiguel@london.edu, Alberto Martin-Utrera, Raman Uppal

Smart-beta providers exploit characteristics such as size, value, and momentum, while other financial institutions provide liquidity for smart-beta trades. We study the effect of competition between smart-beta and liquidity providers. A liquidity provider competing with a single smart-beta provider reduces liquidity by half compared to the centralized setting. However, competition amongst smart-beta providers restores liquidity almost to that in the centralized setting, transferring profits to liquidity providers. Thus, a regulator concerned with the quality of smart-beta products available to retail investors should limit excessive competition amongst smart-beta providers.

2 - The Network of Firms Implied by the News

Hannan Zheng, PhD Candidate, Boston University, Boston, MA, United States, zhannan@bu.edu, Gustavo Schwenkler

We show that the news reports about distressed links between firms that facilitate contagion in financial markets. News-implied contagion generally flows from a smaller to a larger linked firm and generates predictability in stock returns and bond spreads. We show that the degree of connectivity in the news-implied network of firms is related to measures of financial uncertainty and contagion, and is predictive of adverse macro-economic outcomes. To obtain our results, we develop a machine learning methodology that takes text data as input and outputs a network of firm links implied by the data. These results enable the accurate estimation of firm-level and aggregate risks.

3 - Large Dimensional Latent Factor Modeling with Missing Observations and Applications to Causal Inference

Ruoxuan Xiong, Stanford University, Stanford, CA, 94305, United States, rxiong@stanford.edu, Markus Pelger

This paper develops the inferential theory for latent factor models estimated from large dimensional panel data with missing observations. We propose to estimate the latent factor model by principal component analysis of an adjusted covariance matrix estimated from the partially observed panel data. We derive the asymptotic distribution for the estimated factors, loadings and imputed values under a general approximate factor model. One key application is to estimate counterfactual outcomes and test for individual treatment effects at any time. We study the effect of academic publications on the risk premium of anomaly returns and find that around 15% is significantly reduced by the publication.

4 - Deep Learning for Predicting Asset Returns

Guanhao Feng, City University of Hong Kong, Hong Kong, China, He Jingyu, Nicholas Polson

Deep learning is useful to stock return prediction and requires a large sample for model training. We find out, the commonly used pooled model training in deep learning fits well with large variance stocks (low market equity) but underfits small variance stocks (high market equity). Inspired by Bayesian hierarchical modeling and seemingly unrelated regressions (SUR), we propose a deep learning SUR approach (DL-SUR) that shares information across different stocks while train each stock separately. We create a two-pass neural network to combine pooled modeling and individual time-series modeling with the ``warm starting". In a comprehensive empirical study, we compare pooled, time-series, and DL-SUR model prediction performances for U.S. equity returns. Lastly, our proposed method achieves better performance for small variance stocks and higher Sharpe ratio in value-weighted portfolios.

■ MA08

CC- Room 211

Recent Advances in Nonconvex Programming for Machine Learning

Emerging Topic: Artificial Intelligence & Machine Learning

Emerging Topic Session

Chair: Miju Ahn

1 - Estimation of Shape Constrained Index Models

Ying Cui, University of Southern California, Los Angeles, CA, United States, yingcui@usc.edu

Index models are very popular in econometrics and statistics. Most methods that have been proposed in the literature use kernel smoothing to estimate these models, which are not computationally efficient for high dimensional problems. In this paper, we show that a simple assumption of convexity or difference-of-convexity of the regression function enables one to fit such models by modern optimization techniques. A majorization-minimization method to solve the resulting nonconvex constrained nonsmooth optimization problems, where the convex subproblems are solved by a nonsmooth-Newton based augmented Lagrangian method.

2 - Risk Measures and Machine Learning: New Approaches and Algorithms

Matthew Norton, Naval Postgraduate School, Monterey, CA, United States

We discuss some recent developments in Risk Management that have helped to improve and interpret ML algorithms. We first look at a suite of new performance metrics for regression and classification derived from Buffered Probability of Exceedance. We show that these new metrics are simple to optimize, lead to efficiently solvable classification/regression problems, and provide new interpretations of SVM's. Next, we see that new developments have also reached into Deep Learning, with new risk measures giving rise to Generalized Batch Normalization, a new layer in Deep Neural Network architectures that can help increase speed of convergence and improve predictive performance.

3 - Efficient Individualized Decision Rules Estimation Using Bi-level Optimization

Yifan Cui, Wharton School of the University of Pennsylvania, Philadelphia, PA, United States, cuiy@wharton.upenn.edu, Ying Cui, Zhengling Qi

In many applications such as precision medicine, people are interested in learning individualized decision rules (IDRs) from observational studies. This problem becomes very challenging when both the propensity score cannot be consistently estimated and a large number of baseline covariates exist. In this paper, relying on the linearity assumption on the outcome model, we develop a $\sqrt{n}$-efficient learning procedure for optimal IDRs under high-dimensional settings without estimating the propensity score. By leveraging bi-level optimization techniques, the proposed learning procedure performs the evaluation and search of IDRs simultaneously.

4 - Robust Training of Neural Networks: A Game Formulation with Convergence Guarantees

Tianjian Huang, University of Southern California, Los Angeles, CA, United States, tianjian@usc.edu

Recent adversarial attacks on neural networks raise significant concerns about the reliability of these models in critical applications. In this work, we introduce a novel algorithm for training neural networks which are robust against adversarial attacks. The proposed algorithm is based on a game formulation where each adversary player attempts to change the label to a particular target label. Our numerical experiments demonstrate that the proposed algorithm achieves the state-of-the-art performance. In addition, the proposed method have theoretical convergence guarantees. It is scalable, and does not require heavy parameter tuning.

■ MA09

CC- Room 212

Business Value of Crowd Intelligence

Sponsored: Artificial Intelligence

Sponsored Session

Chair: Xuan Wei, University of Arizona, Tucson, AZ, 85721, United States

Co-Chair: Zhengchao Yang, University of Arizona, Tucson, AZ, 85281, United States

1 - Does Crowdsourced Content Contribute to Public Benefits? Its Effectiveness in Relieving Traffic Congestion around Urban Areas

Tae Hun Kim, Baylor University, Waco, TX, 76798, United States, taehun_kim@baylor.edu, Chenhui Guo, Vallabh Sambamurthy

We address how real-time content, crowdsourced by Waze users, impacts traffic congestion around urban areas. We utilize large-scale data on hour-by-hour content production activities and locations of Waze users in New York City (NYC) and apply the spatial panel data approach to estimate the contribution of content production to traffic mobility around NYC. Our findings reveal that the crowdsourced content creates public benefits by reducing the duration of traffic congestion: although a minority of drivers use Waze and crowdsource the traffic-related content, the benefits from the content in the form of reduced duration of traffic congestion eventually extend to the majority of drivers in NYC.

2 - When E-government Meets Crowd Intelligence: Literature Review and Research Prospection

Xiaoyang Chen, Tsinghua University, Beijing, China, chenxiaoyang111@outlook.com, Nan Zhang, Qingguo Meng

Crowd intelligence, also mentioned as collective intelligence or swarm intelligence in the prior literature, is defined as a blend of "information, technology and participants" to produce better decisions for responding to complex social problems. For understanding and exploring the public value of crowd intelligence, some theoretical considering from public management and politics could seem as another dimension besides technological capacities, as the same as e-government. In this paper, we will review the related literature from the different research areas, and propose some future orientations about crowd intelligence in public administration based on the literature.

3 - The Dark Side of Images: The Effect of Customer Generated Images on Product Ratings

Yue Guan, Tsinghua University, Beijing, China, Yong Tan, Qiang Wei, Guoqing Chen

Customer Generated Image (CGI) on e-commerce platforms has been widely recognized as a marketing tool to persuade customers into purchases. Despite its wide application, the effect of CGI on post purchase satisfaction has seldom been examined in academia. This study draws upon consumer psychology theory, employs a difference in differences model with propensity score matching method and finds that CGIs could lead to lower subsequent product review ratings compared with those not exposed to CGIs. Additional analysis indicates that this negative effect could depend on factors such as review ratings, human faces, or the quality of CGI.

4 - Crowd-Powered False News Detection in Social Media

Xuan Wei, University of Arizona, Tucson, AZ, 85721, United States, weix@email.arizona.edu, Zhu Zhang, Dajun Daniel Zeng

We investigate false news, a global concern attracting significant attention lately. The prevalence of false news in social media has severe consequences in many areas. Human knowledge and intelligence hold great potential to complement machine-based methods. Yet, they are largely under-explored in current false news detection research. We observe that the crowd contributes to the challenging task of assessing the veracity of news by posting responses or reporting. Through application of appropriate analytical techniques such as the proposed framework as reported in this manuscript, crowd intelligence can be fruitfully integrated with machine intelligence to tackle false news detection.

5 - The Impacts of Social Focus of Crowds on Hotelpopularity

Yiyang Bian, Nanjing University, Nanjing, China, Jianwei Liu

We explore how social focus and linguistic style in online customers' discussion contents influence hotel popularity. Few studies investigated differential effects of narrative style and social focus orientation on hotel popularity. This study generalizes the systematic-related and heuristic-related characteristics from the discussion contents in online tourism forum. Drawing on Heuristic-Systematic Persuasion Model, we investigate how these two types of cues influence hotel's popularity degree and online reputation.

■ MA10

CC- Room 213

Innovation Technologies

Sponsored: Analytics

Sponsored Session

Chair: Aaron Burciaga, Analytics2Go, Tysons, VA, 22102, United States

1 - Impending Revolution in Talent Management that put the Data Scientist FIRST

Lance Kallaman, President, DataPrime, Los Angeles, CA, United States

Companies often can't fill Data Science jobs fast enough because of the shortage of talent. That doesn't mean they can't acquire the types of skills data scientists typically possess. It takes creative thinking, persistence, and a new approach. Hiring the right Data Scientist is hard! Hiring managers need more accurate assessments of data science skills required of the role they are hiring and to have Data Science candidates presented with capabilities and strengths highlighted. Data Scientists want an accurate understanding of the role, culture, and career value of the opportunity and an understanding of their skills in relation to the opportunity and Data Science community at large. Meeting the needs of the market requires a revolution in how Data Science talent is identified, assessed, hired, incentivized, developed, and retained. Lance will share how this revolution in Data Science talent management can be delivered through Talent Agency, Job Placement, and Career Development services.

2 - Approaches in Building Machine Learning Products and Teams

Andrew Musselman, Owner & Director, BetaSoftware, Seattle, WA, United States

The fervor of Artificial Intelligence and Machine Learning, and Analytics have led to a bumper crop of education, training, tools, methods, and promised results. This presentation will cut through the hype and will share case studies of how commercial programs have achieved actual, documented, and enduring results in the development of their analytics programs. Best practices for developing elite teams will be shared along with business practices and techniques for optimizing the delivery of world-class talent, projects, and products.

■ MA11

CC- Room 214

Analysis and Control of Stochastic Systems

Sponsored: Applied Probability

Sponsored Session

Chair: Jiheng Zhang, Hong Kong University of Science and Technology, Sai Kung, Hong Kong

1 - Sizing Flexible Resources in Large-scale Service Systems

Jinsheng Chen, Columbia University, New York, NY, United States, jc4823@columbia.edu, Jing Dong

Service systems typically involve multiple classes of customers, each requiring a different type of service. Flexible (multi-skilled) servers can improve system performance as they can help an overloaded pool during queue imbalances. However, they may be more costly than dedicated (single-skilled) servers, or work at a slower rate. We analytically determine the optimal staffing levels of flexible and dedicated resources using an asymptotic approach. We find that the optimal staffing levels and the behavior of the system depend critically on which of two regimes the system parameters fall under.

2 - On-demand Matching in a Spatial Model with Abandonment and Cancellation

Guangju Wang, Hong Kong University of Science and Technology, Hong Kong, Hong Kong, gwangal@ust.hk, Hailun Zhang, Jiheng Zhang

Car-hailing platforms have a profound impact on the way people travel and commute. As an intermediary between passengers and drivers, a platform gathers location information from both sides and makes on-demand matchings upon passengers' requests. Optimization of such matching decisions is challenging because of the complex system dynamics. We first propose a spatial model to approximate the pick-up distance of a matching and analyze the queueing dynamics, where the platform can control the matching process according to the pick-up distance. Based on the fluid approximation of the system, we find a simple optimal condition and propose a self-adaptive policy to find the optimal pick-up distance.

3 - Control of Fork-join Processing Networks with Multiple Job Types and Parallel Shared Resources

Erhun Ozkan, Koç University, College of Admisnitrative Sciences, Istanbul, 34450, Turkey, erhozkan@ku.edu.tr

A fork-join processing network is a queueing network in which tasks associated with a job can be processed simultaneously. Fork-join processing networks are prevalent in computer systems, healthcare, manufacturing, project management, justice system, etc. In a fork-join processing network, jobs arriving in the system fork into arbitrary number of tasks, then those tasks are processed in parallel, and then they join and leave the network. There are shared resources processing multiple job types. We study the scheduling problem for those shared resources (that is, which type of job to prioritize at any given time) and propose an asymptotically optimal scheduling policy in diffusion scale.

4 - Dynamic Scheduling of Multiclass Many-server Queues with Abandonment: The Generalized Gc /h Rule

Hailun Zhang, Hong Kong University of Science and Technology, Clear Water Bay, Hong Kong, Hong Kong, hzhangaq@connect.ust.hk, Zhenghua Long, Nahum Shimkin, Jiheng Zhang

We consider the problem of server scheduling in a G/M/n+GI queue with multiple customer classes based on the analysis of the associated fluid model.For the purpose of minimizing the long-run average queue length costs and abandon penalties, we first introduce the target-allocation policy and prove its optimality for any general queue length cost functions and patience time distributions.The Gc /h rule, which extends the well-known Gc rule by taking abandonment into account, is shown to be optimal for the case of convex queue length costs and nonincreasing hazard rates of patience. Numerical experiments show that this hybrid policy performs satisfactorily.

■ MA12

CC- Room 2A

Experimentation, Learning, and Estimation

Sponsored: Applied Probability

Sponsored Session

Chair: Mohammad Rasouli, Stanford University, Palo Alto, CA, 94306, United States

1 - Experimenting in Equilibrium

Kuang Xu, Stanford Graduate School of Business, Stanford, CA, 94305, United States, Stefan Wager

We study experimental design in large-scale stochastic systems with substantial uncertainty and structured cross-unit interference. We consider the problem of a platform that seeks to optimize supply-side payments p in a centralized marketplace where different suppliers interact via their effects on the overall supply-demand equilibrium, and propose a class of local experimentation schemes that can be used to optimize these payments without perturbing the overall market equilibrium. We show that, as the system size grows, our scheme can estimate the gradient of the platform's utility with respect to p while perturbing the overall market equilibrium by only a vanishingly small amount.

2 - Generalization Error and Estimate Consistency

Assaf Zeevi, Columbia University, New York, NY, 10027, United States

We present some observations that connect classical asymptotic estimation theory and modern finite sample approaches, and allow a better characterization and understanding of the generalization error in statistical learning. In particular, we investigate simple structural conditions on the loss function under which finite sample generalization bounds are valid, and show that estimator consistency implies ``fast rates" of convergence for the excess risk, as well as asymptotically optimal finite sample bounds. These results substantially improve generalization bounds of many important problems.

3 - Prepivoting in Finite Population Causal Inference

Colin B. Fogarty, Massachusetts Institute of Technology, Cambridge, MA, United States

In finite population causal inference, randomization alone can be employed as a basis for statistical inference. In this framework exact tests facilitated through randomization-based inference are generally justified only under sharp null hypotheses - null hypotheses that specify the potential outcomes. That said, inference is often desired for the average of the treatment effects while leaving the particular pattern of effect heterogeneity unspecified. We present a broadly applicable testing procedure that is finite sample exact for sharp null hypotheses while retaining asymptotic validity under weak nulls by employing a bootstrap prepivoted test statistic.

4 - Adaptive Experimental Design with Temporal Interference

Mohammad Rasouli, Stanford University, Palo Alto, CA, 94306, United States, rasoulim@stanford.edu, Peter W. Glynn, Ramesh Johari

In experimenting dynamic systems, treatment and control can change the state of the system (e.g. pricing algorithm of a ridesharing system, matching algorithm of a delivery system, or reserve price in ad auctions) resulting in temporal interference. We model it as estimating the difference of the steady state reward between two different policies in a Markov chain with unknown transitions and rewards that depend on the actions (treatment or control). We characterize the adaptive experimental design and estimator that are consist and efficient. For practical implementation, we propose alternative estimators and corresponding optimal policies, and study the efficiency gap of these designs.

■ MA13

CC- Room 2B

Behavioural Queueing Science

Sponsored: Applied Probability

Sponsored Session

Chair: Galit Bracha Yom-Tov, Technion - Israel Institute of Technology, Haifa, 32000, Israel

1 - Managing Capacity Utilization in Service Platforms

Marcelo Olivares, Associate Professor, Universidad de Chile, Beaucheff 851, Of 624, Santiago, Chile, molivares@uchile.cl

In service systems with variable demand capacity decisions require making a trade-off between the responsiveness to customers versus operating costs of labor. To break this trade-off, the service system can operate as a platform with access to a large pool of employees with flexible working hours that are compensated through piece-rates. In this setting a new trade-off emerges between capacity utilization and worker turnover. We analyze this trade-off using data from an outbound call-center that operates with a pool of flexible agents working remotely.

2 - Waiting in Queues: Predictions and Decisions

Gad Allon, University of Pennsylvania, Philadelphia, PA, 19104, United States, gadallon@wharton.upenn.edu, Mirko Kremer, Achal Bassamboo

We study how customers form beliefs while waiting in line in a lab setting. In particular, we study the impact of these beliefs formation processes about decision-making and the impact of the prospect of making a decision on the quality of the predictions.

3 - On Withholding Capacity from Strategic Patients

Mor Armony, New York University, New York, NY, 10012, United States, marmony@stern.nyu.edu, Yunchao Xu, Nan Liu

Common wisdom suggests that everything else being equal, seeing patients sooner rather than later is preferable. In particular, health outcomes improve with reduced delay and so does patient satisfaction. At the same time, if the delay in access to care is reduced, patients may be more inclined not to show up for their appointments given that rescheduling will not result in excessive wait. We investigate how an outpatient care provider should manage capacity in the presence of such strategic behavior of patients. We find that under some circumstances, it is optimal for the service provider to withhold capacity from patients in order to elicit them to show up for their scheduled appointments.

4 - Nudging Patient Choice: Evidence from a Field Experiment

Jiayi Liu, Emory University, Atlanta, GA, United States, Diwas S. Kc

To examine the drivers of patient no-shows at outpatient clinics, we conduct a series of field experiments where the messaging regarding their upcoming appointment is randomly assigned. We find that the type of messaging has a significant effect on the queuing behavior of individuals, most notably their no-show behavior.

■ MA14

CC- Room 302

Behavioral Dynamics in Various Contexts

Sponsored: Manufacturing & Service Oper Mgmt

Sponsored Session

Chair: Dayoung Kim, California State University-Fullerton, Fullerton, CA, 92831, United States

1 - Gamesmanship Behavior in Supply Chain Competition

Mohsen Ahmadian, PhD Student, University of Massachusetts-Boston, Boston, MA, 02215, United States, mohsen.ahmadian001@umb.edu, Ehsan Elahi, Roger H. Blake

In the context of simultaneous competition, this paper investigates decision-makers' tendency to focus on exceeding their competitors' payoffs rather than maximizing their own payoff. Considering this tendency, we introduce a new type of competition equilibrium, which assumes each decision-maker's objective is to maximize the difference between his own and his competitors' payoff in his favor. We term this equilibrium gamesmanship equilibrium and introduce its general formulation. We then use controlled laboratory experiments to investigate how well the gamesmanship equilibrium fares in explaining the subjects' behavior under three different outsourcing competition setups.

2 - Nudging Organizations: Evidence from Three Large-scale Field Experiments

James Fan, Naval Postgraduate School, Monterey, CA, 93940, United States, james.fan@nps.edu, Paul Ferraro, Kent Messer, Collin Weigel

Nudges and changes to choice architecture can affect individual behaviors. However, whether the same interventions are equally effective in changing the behaviors of groups of individuals acting as organizations is an open question. In three natural field experiments, local organizations make decisions about whether to contribute financially to a national coordinating organization. We test the efficacy of five behavioral nudges. Compared to the estimated treatment effects of similar interventions among individuals, our estimated effects on organizations are dramatically smaller and of the opposite sign.

3 - Taxi Drivers Minimize on Waiting Time Because of its Salience Rather Than on Earnings Resulting in Adverse Economic and Environmental Impacts

Lawrence Jin, National University of Singapore, Singapore, Singapore

We analyze more than 140,000 decisions by 3,000 taxi drivers at Singapore's Changi airport and find that information saliency causes drivers to make suboptimal decisions. Taxi drivers minimize the waiting time for their next passenger, and overlook the significantly higher fares that they can earn from the airport compared to other locations. As a result, many taxis do not wait at the airport for passengers. Correcting this mistake would increase taxis' earnings by SG$1.8 million per year in Singapore. Taxis would also drive 2.8 million fewer kilometers per year, which translate into an annual saving of SG$800,000 in maintenance plus fuel costs and reduce air pollution.

4 - Effect of Experiential Learning in Teaching Process Management

Naser Nikandish, California State University, Fullerton, CA, 92831, United States, Dayoung Kim

This project examines effectiveness of outside class experiential learning exercise on teaching process management topics in an undergraduate level operations management course. We conduct this experiment in two classes of different sizes. After teaching process management topics in the form of traditional theoretical presentation, students are offered an optional exercise outside the classroom to analyze a real process. Then we measure students understanding in a follow up midterm exam. We found out that the students who conducted the outside classroom experiential learning exercise performed significantly better than students who did not participate in this exercise.

5 - The Behavioral Traps in Making Multiple, Simultaneous, Newsvendor Decisions

Shan Li, Baruch College, City University of New York, Baruch College, New York, NY, 10010, United States, shan.li@baruch.cuny.edu, Kay-Yut Chen

This paper conducted an experimental study to explore behaviors of newsvendors who make order decisions for two products simultaneously. Our study has implication on how multiple products should be grouped and managed.

■ MA15

CC- Room 303

Data Driven Research in Supply Chains

Sponsored: Manufacturing & Service Oper Mgmt

Sponsored Session

Chair: David Simchi-Levi, Massachusetts Institute of Technology, Dept of Civil and Environmental Engineering, Cambridge, MA, 02139, United States

1 - Phase Transitions and Cyclic Phenomena in Bandits with Switching Constraints

David Simchi-Levi, Massachusetts Institute of Technology, Institute for Data, Systems, and Society, Cambridge, MA, 02139, United States

We consider the classical stochastic multi-armed bandit (MAB) problem with a constraint on the total cost incurred by switching between actions. The model is motivated by an industry collaboration, where the online retailer applies dynamic pricing with demand learning but limits the number of price changes. We prove matching upper and lower bounds on regret and provide near-optimal algorithms for this problem. Surprisingly, we discover phase transitions and cyclic phenomena of the optimal regret. That is, we show that there are phases defined by the number of arms and switching costs, where the regret upper and lower bounds in each phase remain the same and drop significantly between phases.

■ MA16

CC- Room 304

New Trends in Service Design and Pricing

Sponsored: Manufacturing & Service Oper. Mgmt/Service Operations

Sponsored Session

Chair: N. Bora Keskin, Duke University, Durham, NC, 27708-0120, United States

Co-Chair: Yuan-Mao Kao, Duke University, Durham, NC, 27705, United States

1 - Fair Lending to Small Farmers

Deeksha Sinha, Massachusetts Institute of Technology, Cambridge, MA, 02139, United States, deeksha@mit.edu, Vivek Farias, Disha Bhanot

In this work, we build a fair credit scoring mechanism that can be used for financing small farmers. Small farmers constitute the majority of farmers in developing countries. These farmers rely heavily on loans for growing crops. A credit scoring mechanism which appropriately captures their willingness to pay and does not penalize them for factors beyond their control like weather conditions, crop prices is desired. These accurate risk estimates can then be used to design loans which satisfy the farmers' needs at an interest rate matching their credit-worthiness. We have partnered with a large public sector bank in India which has a strong presence in the agricultural lending sector.

2 - Product Quality in a Supply Chain with Social Learning

Dongwook Shin, HKUST Business School, Lee Shau Kee Building, Hong Kong University of Science and Technology, Clear Water Bay, Hong Kong, dwshin@ust.hk, Assaf Zeevi

This paper investigates the manufacturer's incentive to improve quality, which sells its product to customers via an online retailer. The online retailer provides a product review system where customers can share their experience of the product. The manufacturer may not have full information about customer demand. In contrast to conventional knowledge, we show that the presence of online reviews may deteriorate the product quality in online markets.

3 - Can Two Competing On-demand Service Platforms Both Be Profitable?

Jiaru Bai, Wake Forest University, Winston Salem, NC, United States, baij@wfu.edu, Christopher S. Tang

As venture capital firms are financing on-demand service platforms, we wonder how many startups of this kind can survive in a competitive market. To examine this question, we present a model in which two on-demand service platforms compete in both the provider and customer markets.

4 - Bayesian Dynamic Pricing and Subscription Period Selection with Unknown Customer Utility

Yuan-Mao Kao, Duke University, Durham, NC, 27705, United States, yuan.mao.kao@duke.edu, N. Bora Keskin, Kevin Shang

We consider a firm that aims to determine the price and service duration for a subscription service. The firm faces uncertainty regarding its customers' preferences and can accumulate information through sales and usage observations over time. We derive an efficient method to obtain the firm's optimal policy in the presence of perfect information on customer preferences. We also construct and analyze a near-optimal policy for the case of imperfect information.

■ MA17

CC- Room 305

Joint Session MSOM/SERV OP/Practice Curated: Empirical Studies on the Design of Online Marketplaces

Sponsored: Manufacturing & Service Oper. Mgmt/Service Operations

Sponsored Session

Chair: Chiara Farronato, Harvard Business School, Boston, MA, 02163, United States

1 - Online Reviews as Barriers to Entry

Chiara Farronato, Harvard Business School, Soldiers Field Road, Morgan Hall 412, Boston, MA, 02163, United States

We explore entry barriers induced by online reputation systems. We first provide descriptive evidence from an online platform that new sellers have increasing difficulty in making their first sales. The interval between entry and first sale increases over time and is longer in categories where a larger share of sellers have high ratings or for categories with longer histories. We plan to test whether barriers to entry are induced by the design of online review systems by conducting an experiment. In particular, we plan to test whether adding recent seller ratings to the information disclosed to consumers increases buyers' propensity to choose new suppliers relative to older and established suppliers.

2 - The Role of Feedback in Dynamic Crowdsourcing Contests: A Structural Empirical Analysis

Zoey Jiang, University of Michigan-Ann Arbor, Ann Arbor, MI, 48104, United States, jiangzh@umich.edu, Yan Huang, Damian Beil

We empirically examine the impact of feedback on the outcome of crowdsourcing contests. We develop and estimate a dynamic structural model using a rich data set about online logo design contests. The model captures key features of the crowdsourcing context, including a large participant pool, new entries throughout the contest, and the participants' strategic choice among entry, exploration, and exploitation decisions in a dynamic game. We compare alternative feedback policies using counter-factual simulations, and find providing feedback throughout the contest may not be optimal.

3 - The Impact of IPOs on Peer-to-peer Lending Platforms

Maxime Cohen, McGill University, Montreal, QC, 10012, Canada, maxccohen@gmail.com, Kevin Jiao

In this paper, we use a comprehensive dataset from two large peer-to-peer lending platforms. We are facing an interesting situation where one platform went public by filing an IPO, whereas the other platform still remained privately held. We exploit this empirical environment to carefully infer the causal effect of IPOs on peer-to-peer lending platforms.

4 - The Re-design of Framework Agreements Markets in Chile

Marcelo Olivares, Universidad de Chile, Beaucheff 851, Of 624, Santiago, Chile, Eduardo Lara, Daniela Saban, Gabriel Weintraub

Framework Agreements (FAs) are a common procurement mechanism used by governments and large organizations. They are based on an auction-type design to select an assortment of products from multiple suppliers with posted prices, from which organizations can then buy. The Chilean government acquires US$2 billion in goods and services per year using FAs. In this talk, we discuss how we collaborated re-designing the food FA, one of the largest FAs run by the Chilean government. The new FA auction prices decreased by around 25% (in real terms) on average compared to the previous food FA auction that was run before the re-design several years ago.

■ MA18

CC- Room 306

Emerging Topics in Sustainable Operations

Sponsored: Manufacturing & Service Oper. Mgmt/Supply Chain

Sponsored Session

Chair: Somya Singhvi, MIT, Cambridge, MA, 02139, United States

1 - Unifying Agricultural Wholesale Markets: Impact on Farmers' Income

Somya Singhvi, MIT, Cambridge, MA, 02139, United States, ssinghvi@mit.edu, Retsef Levi, Manoj Rajan, Yanchong Zheng

In order to improve farmer welfare, Government of Karnataka in India started integrating all its regulated markets through an online platform (UMP) in 2014. In this work, we empirically examine the impact of UMP on wholesale prices and find that while UMP had a significant impact on farmers' profit margins for some commodities, it had no impact for others. Utilizing proprietary auction data, we provide evidence that systemic supply chain logistics and process design considerations that affect trades in the physical markets are important factors influencing the impact of UMP. We discuss several policy insights related to the design of similar agri-platforms in developing countries.

2 - Improved Crop Yields Through Optimized Planting Schedules

Ying (Maggie) Zhang, Clemson University, Clemson, SC, 29634, United States, ying6@clemson.edu, Jayashankar M. Swaminathan

In this paper, we develop a model to determine the optimal seeding policy under rainfall uncertainty using a finite-horizon stochastic dynamic program. We show that the optimal planting policy is a time dependent threshold-type policy where the farmer should plant when the seed amount on hand is above the optimal threshold. Utilizing field weather data from Southern Africa, in a real size large-scale problem, we demonstrate significant relative yield advantage of the optimal planting schedule over commonly used heuristics in practice.

3 - Process Standardization for Remanufacturing

Cerag Pince, Quinlan School of Business, Loyola University Chicago, Schreiber Center 425, Chicago, IL, 60611, United States, Atalay Atasu, Beril L. Toktay

Remanufacturing is a labor-intensive process. Motivated by a third-party remanufacturer (3PR) of consumer products, we study workforce capacity investment problem in the context of product recovery operations. We analyze how a remanufacturing firm should determine the quantity and type (skilled vs. unskilled) of its workforce when both the number and complexity of units to be processed are random. We characterize the optimal solution along with the conditions when using only one type of workforce dominates the other.

4 - Mechanism Design for Supply Chain Certification Programs

Pia Ramchandani, Wharton School of Business, Philadelphia, PA, United States, piar2@wharton.upenn.edu, Hamsa Sridhar Bastani, Kenneth Moon

Existing certification programs (e.g. Fair Trade, Utz, etc.) that seek to improve human rights and sustainable production may be reaching a plateau in adoption and possibly losing traction, leaving opportunities for mechanism design improvement. Through an empirical analysis on the coffee market, we seek to verify or disprove a series of commonly cited barriers associated with growth of certification programs. We also identify potential targets of certification adoption and investigate their incentives to suggest enhancements for mechanism design.

■ MA19

CC- Room 307

Joint Session MSOM/SC/Practice Curated: Learning to Optimize

Sponsored: Manufacturing & Service Oper. Mgmt/Supply Chain

Sponsored Session

Chair: Max Shen, JD.com, Santa Clara, CA, 95054, United States

Co-Chair: Junyu Cao, Albany, CA, 94706, United States

1 - Online Learning Algorithms for Stochastic Inventory Systems

Cong Shi, University of Michigan, 2257 Woodhaven Ct, Ann Arbor, MI, 48105, United States, Hao Yuan

We consider several periodic-review inventory systems under censored demand. We assume the firm does not know the demand distribution a priori, and makes adaptive inventory ordering decision in each period based only on the past sales (a.k.a. censored demand) data. We develop several nonparametric learning algorithms that combine the powers of stochastic gradient descent, bandit controls, and simulation-based methods. We establish tight or nearly tight regret bounds for the developed algorithms and demonstrate their numerical performance.

2 - Sequential Choice Bandits: Learning with Marketing Fatigue

Junyu Cao, University of California, Berkeley, Berkeley, CA, 94706, United States, jycao@berkeley.edu, Wei Sun, Zuo-Jun Max Shen

Motivated by the observation that overexposure to unwanted marketing activities leads to user dissatisfaction, we consider a setting where a platform offers a sequence of messages and is penalized when users abandon the platform due to marketing fatigue. Based on user feedback, the platform dynamically learns users' tolerance and their valuations of messages to determine the optimal length and the order of the messages, while maximizing the cumulative payoff. We refer to this online learning task as the sequential choice bandit problem, and characterize the regret bound of our proposed algorithm. Lastly, we evaluate the performance of our algorithms with both synthetic and real-world datasets.

3 - Optimization of Tree Ensembles

Velibor Misic, UCLA Anderson School of Management, Los Angeles, CA, 90095, United States, velibor.misic@anderson.ucla.edu

Tree ensemble models such as random forests and boosted trees are often used to predict the effect of different decisions. While such models are widely used for predictions, little is known about how to use them for effective decisions. In this talk, we consider the problem of finding a decision that is optimal with respect to a tree ensemble model. We formulate this problem as a mixed-integer optimization model and present theoretical results on its structure. We test our method on real data sets, including two case studies in drug design and customized pricing, and show that it can efficiently solve large-scale instances to near or full optimality, outperforming heuristic solutions.

4 - A Dimension-free Algorithm for the Contextual Continuum-armed Bandit Problem

Ningyuan Chen, University of Toronto, Clear Water Bay, Toronto, ON, Canada, Jeff Hong, WENHAO LI

In multi-armed bandit problems, when the contextual information and the decision variable are both continuous and high-dimensional, it is known that the optimal rate of regret scales exponentially with both dimensions. In this project, we show that when the objective function is globally concave in the decision variable, we can alleviate the curse of dimensionality.

■ MA20

CC- Room 308

Joint Session INFORMed/Practice Curated: Activities in the Classroom

Sponsored: Education

Sponsored Session

Chair: Michael J Racer, University of Memphis, Memphis, TN, 38152, United States

1 - Developing a Blog for High School Calculus Students

Michael J. Racer, University of Memphis, 302 Fogelman College of Business, Memphis, TN, 38152, United States, Anne Papakonstantinou

We want to introduce an activity they we are starting in the INFORMS to help high school students become better at developing calculus models. We are created a sample blog and want to show it to members of Informs. Then will developing a list of teachers at high schools and on a regular basis send them these examples to use in their classrooms. We just want to generate as much support as we can from the Informs community

2 - OR and Computational Science in the UG Curriculum

Allen Holder, Rose-Hulman Institute of Technology, Department of Mathematics, Terre Haute, IN, 47803, United States

Operations research and computational science combine nicely in the undergraduate arena to help prepare students for technical careers and continued education. We will review coursework that has been developed in support of a computational science degree at the Rose-Hulman Institute of Technology. The curriculum combines topics from optimization, statistics, numerical analysis, and computer science, and it supports applications that span science and engineering. The focus is on computational savvy, with material being supported mathematically and discussed algorithmically.

3 - Experiential Learning and Applying OR in Healthcare

Amy Cohn, University of Michigan, Department of IOE, Ann Arbor, MI, 48109, United States

Much of my research is focused on developing, implementing, and applying Operations Research-based decision support tools to solve complex, multi-criteria optimization problems in healthcare. Specifically, I solve personnel scheduling problems such as the assignment of residents to training rotations or attending physicians to clinical unit. This applied research has also presented me with the opportunity to provide experiential learning opportunities to a large number of undegraduates and masters students. They not only learn to address the technical challenges of a complex combinatorial optimization problem, but gain training in multi-disciplinary team work, in problem scoping, in communicating across different fields, and in tackling the practical challenges of implementing a theoretical solution in real-world practice. I will present my experience in working with a large and diverse group of students in such a learning environment and share lessons learned along the way.

4 - Flipping the intro to OR Course

Susan E. Martonosi, Harvey Mudd College, Department of Mathematics, Claremont, CA, 91711, United States

After participating in a semester-long active learning fellowship, I took the plunge and "flipped" my long-standing Intro to OR course. This talk will describe the structure of the course, what went well, and what will be improved in the future. I'll reflect on the importance of space and classroom infrastructure in contributing to the experiment. I'll also describe the ways in which a collaborative and supportive learning community emerged in the course, and how that is important for broadening the participation of underrepresented groups in our profession.

■ MA21

CC- Room 309

iFORM Emerging Research

Sponsored: Manufacturing & Service Oper. Mgmt/iFORM

Sponsored Session

Chair: William Schmidt, Cornell University, Ithaca, NY, 14850, United States

1 - Financing Inventory under Bank Capital Regulation and Seller Orchestration

Yuxuan Zhang, Tsinghua University, Beijing, 100084, China, zhangyux14@mails.tsinghua.edu.cn, Simin Huang, S. Alex Yang

This study examines the value of information updating in a milesteon-based supply chain finance scheme. We find that the value of information increases as the trade process becomes more reliable, and as the value of the traded goods increases signicantly as the order successfully passes the rst milestone. The value of information becomes also higher as the bank's cost of equity increases.

2 - The Linkage Between Primary and Secondary Markets for Eurozone Sovereign Debt: Free Flow or Bottleneck?

Nikolay Osadchiy, Emory University, Atlanta, GA, 30322, United States, Alexander Eisl, Christian Ochs, Marti Subrahmanyam

We investigate the consequences of interlinked sovereign bond markets in the Eurozone for the transmission of yields, liquidity and market conditions, specifically, the impact of sovereign bond auctions on secondary markets and the sovereign's cost of debt. We develop a model of financially constrained primary dealers operating in both primary and secondary bond markets. Our model produces optimal inventory levels for existing- and newly issued bonds that can be related to predictable price movements around new sovereign bond issuance. We find an empirical support for the model and estimate the impact of financial constraints on the cost of debt.

3 - Dynamic Contracting in Multi-level Organizations

Ruiting Zuo, National University of Singapore, Singapore, 138601, Singapore, ruitingz@u.nus.edu, Jussi Keppo, Nizar Touzi

In typical contracting problems, a principal designs a contract and then an agent decides whether to accept it and take corresponding actions or to reject it. We investigate incentive contracts under dynamic actions and a simple organizational structure with an owner of an organization, a manager, and a worker. The owner cannot perfectly observe the manager and worker's actions, and similarly, the manager cannot perfectly observe the worker's actions. We show how the actions of the participants and the costs of their actions interact. We then extend the model to a case with an owner, a manager, and multiple workers.

4 - Operational Disruptions, Firm Risk, and Control Systems

William Schmidt, Cornell University, Ithaca, NY, 14850, United States, Ananth Raman

We empirically examine whether implementing and credibly attesting to having effective internal control systems moderates the impact of operational disruptions on the disrupted firm's risk. We show that firms with such credible control systems experience a materially smaller increase in their risk and a smaller decrease in their market value.

■ MA22

CC- Room 310

Agriculture and Food Supply Chain

Sponsored: Manufacturing & Service Oper. Mgmt/Sustainable Operations

Sponsored Session

Chair: Foad Iravani, University of Washington, Seattle, WA, 98195-3226, United States

Co-Chair: Basak Kalkanci, Georgia Institute of Technology, Atlanta, GA, 30339, United States

1 - Integrated Optimization of Fertilization Application, Cultivation and Harvesting

Yangfang (Helen) Zhou, Singapore Management University, Singapore, Singapore, Onur Boyabatli

Motivated by the fresh produce industry, this paper studies the decisions faced by a farmer growing one single crop: fertilizer application, cultivation and harvesting. We develop a two-stage stochastic program capturing uncertainties in both yield and harvesting labor cost as well as the effect where yield in the second stage is stochastically increasing in the fertilizer application quantity in the first stage. We characterize the farmer's optimal decisions as well as the impact of these two uncertainties on the farmer's optimal decisions and profitability.

2 - Batching for Perishable Products

Arzum E. Akkas, Boston University, Boston, MA, 02142, United States, aakkas@bu.edu, Erol Pekoz

Batching is beneficial in manufacturing systems since it reduces production changeovers and, thus, unit production cost. However, a negative consequence of batching is that it increases inventory which, in particular, can be detrimental for perishable products, because excess inventory erodes shelf lives and, thus, increases expiration levels in the supply chain. In this work, we analyze batching decisions of a manufacturing firm and find that, under a reasonable model, the total inventory cost is 13% higher when expiration in downstream supply chain is ignored, which usually is the case in practice. Our work leverages real inventory data from a food manufacturer.

3 - Food Waste in Agricultural Supply Chains

Elena Belavina, Associate Professor, Cornell University, Ithaca, NY, United States, belavina@cornell.edu

Emission from food waste are a major contributor to global warming. In this talk we will explore how changes in the supply chain impact food waste of each part of the supply chain and resulting overall impact on the emissions.

4 - Analysis of One-Europe Type Policies on Agribusinesses

Shivam Gupta, University of Nebraska Lincoln, COB 511K, Lincoln, NE, 68588, United States, Saurabh Bansal

Market-integrating policies such as the One-Europe policies remove import-export barriers. We discuss how this change of regime affects the prices, focusing on agribusiness domain.

■ MA23

CC- Room 3A

Decision Framing & Problem Formulation

Sponsored: Decision Analysis

Sponsored Session

Chair: Andrea Hupman, University of Missouri-St. Louis, St Louis, MO, 63121, United States

1 - Finding the Right Problem Frame to Manage the Change

Edward Cook, President, The Change Decision, Richmond, VA, United States, ed.cook@thechangedecision.com

Framing a decision problem is not necessarily obvious. A decision analyst may need to explore the placement of the correct frame with the group of stakeholders because often "the problem" presented is not the real problem. In this presentation, we will explore the employment of theory and technique in the pursuit of not only getting to a useful frame for the decision but also the psychology of preparing the group of stakeholders to manage the change. This presentation will include examples the presenter has driven from Fortune 100 companies to small firms to nation-building activities in Iraq.

2 - Improving Counterfactual Forecasting Using Relevance Diagrams

Lucas J. Haravitch, University of Southern California, Los Angeles, CA, United States, lharavit@usc.edu, Ali E. Abbas

To overcome the cognitive complexity associated with counterfactual thinking, we propose relevance diagrams to capture and organize disparate information about the workings of a system. This research considers methods to simplify relevance diagrams by using a Gaussian copula structure of variable dependencies and by exploring approximation methods for eliciting dependencies from forecasters.

3 - A Simulation Approach to Compare Decision Quality of Multiattribute Models with Incomplete Attribute Sets

Sarah A. Kusumastuti, University of Southern California, Los Angeles, CA, United States, kusumast@usc.edu

Empirical evidence suggests that decision makers are ill-equipped to identify all relevant objectives (consequently attributes) in a multiattribute decision problem. The effect of incomplete objective sets is examined using a Monte Carlo simulation by comparing the decision made by a baseline model with a reduced model incorporating only a subset of its attributes. The simulations measure the performance of reduced additive multiattribute models under various characteristics of a decision problem, such as number of objectives, proportion of missing objectives, number of alternatives, intercorrelations among objectives, and use of weight approximation methods (equal or ROC weights).

4 - Sensitivity Analysis to Value Specification and Measurement

Andrea Hupman, University of Missouri-St. Louis, St Louis, MO, 63121, United States, hupmana@umsl.edu, Mitchell A. Millstein

A high quality decision analysis requires careful attention to the specification of values and the measurement(s) used to represent each of the values. In this talk, we consider multi-criteria methods to aggregate a set of values into a total value measure and examine how the inclusion of different criteria affects the ranking of the total value measures. We conduct sensitivity analysis on data from a company that implemented a multi-criteria method to value its customers to inform decisions within the company. The analysis highlights the implications of value inclusion for decision analysis.

■ MA24

CC- Room 3B

MCDM and Medicine / Healthcare: A Mutually Beneficial Relationship- I

Sponsored: Multiple Criteria Decision Making

Sponsored Session

Chair: Evangelos Triantaphyllou, Louisiana State University, Baton Rouge, LA, 70803, United States

Co-Chair: Juri Yanase, Complete Decisions, LLC, Baton Rouge, LA, 70810, United States

1 - A Unified Framework for Preventive Healthcare Service Design: Patient-Physician Collaboration

M Gabriela Sava, Clemson University, College of Business, Clemson, SC, 29634, United States, msava@clemson.edu, Jerrold H. May, Luis G. Vargas, Jennifer Shang, James G. Dolan

As patients are increasingly becoming active participants in making their medical decisions, healthcare providers are increasing their focus on patient-centered care. We propose a new service design for shared decision-making, which incorporates analytically both patients' preferences and physicians' expertise into a joint patient-physician model to assess, aggregate, and synthesize preferences.

2 - Clinical Decision Support System Using MCDM Technique: A Non-invasive Diagnostic Mechanism in Assessing Malignant Potentiality

Debjani Chakraborty, Indian Institute of Technology, Kharagpur, India, Kharagpur, India, drdebjanic@yahoo.co.in

In spite of significant amount of technological advances in cancer research over the past few decades malignancy has potentially raised the death toll across the world owing to its low survival rate. Minimal or non-invasive patient-comfort centric mechanism is popular in early diagnosis of malignancy. A clinical decision support system is proposed which will not only improve diagnostic decisions but also enable doctors to design an improved time saving therapeutic plan of action with minimum subjectivity. The whole process is based on multi-scale data with knowledge fusion of human cognition (experience based subjective impressions of pathologists) and its mathematical representation as MCDM.

3 - A Multi-criteria Ranking Algorithm for Determining Patient-tailored Breast Cancer Therapy

Mostafa Hasan, Wichita State University, Wichita, KS, United States, hasan.bbc@gmail.com, Esra Buyuktahtakin Toy, Elshami Elamin

In this study, we determine a comprehensive set of criteria for selecting the best breast cancer therapy by interviewing medical oncologists. We then present two analytical hierarchy process (AHP) models for quantifying the weights of criteria for breast cancer treatment. Using the weights of criteria from the AHP model, we propose a new multi-criteria ranking algorithm (MCRA), which evaluates a large variety of patient scenarios and provides the best patient-tailored breast cancer treatment alternatives based on the input of nine medical oncologists. The MCRA could be used as an accessible decision-support tool to aid oncologists and educate breast cancer patients.

4 - Optimization of Intensity-modulated Proton Therapy Considering the Biological Effect

Gino J. Lim, University of Houston, Dept of Industrial Engineering, Houston, TX, 77204, United States, ginolim@uh.edu, Xuemin Bai, Wenhua Cao

Linear energy transfer (LET) guided methods have been applied to intensity-modulated proton therapy to achieve a higher biological. It's noticed that using LET as a surrogate will increase the model complexity and ignore the difference between dose and LET distribution, which is a more fundamental property. This study focuses on the potential benefits of LET keep going up after the physical dose Bragg Peak to avoid high values of LET in critical structures located within or near the target and increase LET in the tumor area, without compromising the target coverage.

■ MA25

CC- Room 401

Disaster Preparedness and Response through Optimization

Emerging Topic: Humanitarian and NotforProfit Operations

Emerging Topic Session

Chair: Elise Miller-Hooks, George Mason University, Silver Spring, MD, 20905, United States

1 - A Multi-stage Stochastic Programming Model for Relief Distribution Considering the State of Road Network

Zhijie Dong, Texas State University, San Marcos, TX, 78640, United States, sasha.dong@txstate.edu, Shaolong Hu

As an important aspect in disaster operations management, relief distribution has been challenged by many factors. A multi-stage stochastic programming model is developed for disaster relief distribution with consideration of multiple types of vehicles, fluctuation of rental, and the state of road network. The state of road network is characterized using uncertain and dynamic road capacity. The scenario tree is employed to represent the uncertain and dynamic road capacity, and demonstrate the decision process of relief distribution. A progressive hedging algorithm (PHA) is proposed to solve the proposed model in large-scale size with an application in Ya'an earthquake in China.

2 - Management of Interdependent Infrastructure Networks under Disaster Related Uncertainties

Tugce Canbilen, Middle East Technical University, Universiteler Mah. Dumlupinar, Bul. ODTU Kampusu Endustri, Ankara, 06800, Turkey, canbilen@metu.edu.tr, Sakine Batun, Melih Celik

After a disaster, multiple infrastructures have disruptions in their services. During the restoration of these services, we need to consider the operational and restoration independencies among these infrastructures. In this study, the problem under consideration is Interdependent Infrastructure Restoration with disaster related uncertainties. We propose a two-stage program for this problem. In the presentation, we will present how the network reinforcement decisions change according to the network interdependency and uncertainty.

3 - Post-disaster Inspection and Restoration Prioritization in Roadway Networks

Bahar Shahverdi, George Mason University, 4738 Forestdale Dr, Fairfax, VA, 22032, United States, bshahver@masonlive.gmu.edu, Elise Miller-Hooks, Hsi-Hsien Wei

We present mathematical techniques to prioritize post-disaster inspection and roadway restoration activities to mitigate the event's effects on the performance of traffic and other lifelines while maximizing opportunities for completing repairs in a timely manner.

4 - Managing Humanitarian Logistics Through Public-private Partnership: A Collaborative Decision-making Approach to the Pre-positioning of Hurricane Relief Kits

Yue Ge, Assistant Professor, University of Central Florida, Orlando, FL, United States, yue.ge@ucf.edu, Sara Iman, Joseph Szmerekovsky

Business participation in disaster relief pre-positioning and procurement planning is crucial but understudied. This study examines the current pattern of public-private partnerships contributing to humanitarian logistics in hurricane relief efforts in Florida. A dynamic framework is proposed for collaborative decision-making among government, businesses, and other stakeholders that support disaster relief efforts. It is expected that building collaborative emergency preparedness will lead to the reduction of the socioeconomic costs in managing disaster response and the improvement of emergency management performance. A pilot study of Hurricane Irma response is included.

5 - Fuel Distribution Planning for Islands

Vahid Eghbal Akhlaghi, University of Iowa, Iowa City, IA, United States, vahid-eghbalakhlaghi@uiowa.edu, Ann Melissa Campbell, Renato E. de Matta

In this study, we propose an optimization approach for the storage and distribution problem of fuel for disaster recovery on islands under a variety of possible disaster scenarios. We examine Puerto Rico's fuel reserves and how their storage locations may have influenced the recovery from different hurricanes. We develop a mixed integer program to determine an efficient delivery scheme. This model involves evaluating the tradeoff between risk level and transportation costs and ensuring equity and fairness in allocating fuel to affected areas.

■ MA26

CC- Room 4C-1

IBM Best Student Paper Award I

Sponsored: Service Science

Sponsored Session

Chair: Aly Megahed, IBM Research - Almaden, San Jose, CA, 95123, United States

Co-Chair: Paul R. Messinger, University of Alberta, Edmonton, AB, T6G 2R6, Canada

1 - IBM Best Student Paper Award

Paul R. Messinger, University of Alberta, Faculty of Business, 3-20e Faculty of Business Bldg, Edmonton, AB, T6G 2R6, Canada, paul.messinger@ualberta.ca

From a highly competitive pool of submissions, a set of finalists has been selected by a panel of Service Science Section Leaders. In this session, these finalists will present their research findings to a panel of judges and a general audience. This award recognizes excellence among the section's student members and brings prestige to the Service Science Section as well as to the recipients honored.

■ MA27

CC- Room 4C-2

Artificial Intelligence and Machine Learning in Service

Sponsored: Service Science

Sponsored Session

Chair: Yixuan Ma,University of California, Irvine, CA, United States

Co-Chair: Zhenji Zhang, PhD, Beijing Jiaotong University

1 - What Can Images Tell Us: A Predication Study Based on Facial Analysis

Hongfei Li, School of Business, University of Connecticut, School of Business, 2100 Hillside Road, Storrs, CT, 06269, United States, hongfei.li@uconn.edu, Fangda Han, Shun-Yang Lee, Jing Peng

Cosmetic surgery is a type of highly risky service and consumers usually suffer from an unsatisfying consequence after taking surgery. In this paper, we manage to predict consumers' post-surgery appearance based on other consumers' cases by deep learning. Specifically, we utilize generative neural networks (GANs), one type of generative model to automatically generate the post-surgery face given the pre-surgery face image. We design experiments to show that our method can increase consumers' purchase intention. Cosmetic surgery platform or service provider (i.e., hospitals) can leverage our technique to predict consumers' post-surgery images when they are making their purchase decision.

2 - Extending Discrete Choice Model Using Deep Learning

Yixuan Ma, UC Irvine, Irvine, CA, 92617, United States
Yixuan Ma, Beijing Jiaotong University, Beijing, China, Zhenji Zhang, Alexander Ihler

Human choice is hard to predict since the utility of individual depends on alternatives in a complex way. Classical discrete choice models, in particular conditional logit model (CLM), use simple linear utility function, which might not hold in reality. We extend CLM using convolutional neural networks, recurrent neural networks, and residual neural networks to deal with utility nonlinearity. Our methods combine the strengths of deep learning methods, such as flexible representations and improved accuracy, with those of choice models, such as ability to handle variable pool sizes. We test the models on three datasets. Results show that extended choice models outperforms the CLM.

3 - Decision Model in Earthquake Emergency Rescue Based on Deep Belief Network

Rui Fan, Beijing Jiaotong University, Beijing, China

The lack of information after the earthquake has made it difficult for policy makers to make timely decisions, resulting unnecessary losses and damages. In this study, we firstly analyzed the components and extracted a series of visual data of earthquake emergency rescue decision-making process. Then we used Deep Belief Network to deal with data mining problem and established a seismic emergency rescue case library. We improved the similarity evaluation function by combining the traditional Case-Based Reasoning technology with the Deep Belief Network (DBN-CBR). The proposed model was verified using actual data of Yushu earthquake.

4 - Ontology-based Knowledge Base Construction for Public Emergencies in Beijing

Haoyu Gui, Student, Beijing Jiaotong University, Beijing, China, 17120610@bjtu.edu.cn, Dan Chang

Facing with a series of unexpected incidents with complex reasons, it is difficult to propose a reasonable decision accurately based on traditional database. The knowledge base can be seen as a useful tool to store massive data, semantic analysis of the corresponding data, propose an optimal decision-making scheme, and improve the accuracy of emergency decision-making. In this study, based on historical emergency cases, we used ontology technology to represent terms and knowledge in a structured shared conceptual system, established the emergency knowledge base for public emergencies, and gave a practical application of improving the use of knowledge in emergency process in Beijing.

■ MA28

CC- Room 4C-3

Economics of Information Systems

Sponsored: Service Science

Sponsored Session

Chair: Fengmei Gong, University of La Verne, La Verne, CA, 91750, United States

1 - Impacts of Social Systems on User Retention: The Case of Guild System and Friends System in Online Game

Insung Hwang, McGill University, Montreal, QC, Canada, Insung.hwang@mail.mcgill.ca, Kunsoo Han, BeomSeok Kim

User retention in a game is critical because it is strongly correlated with the game's success. In this study, we investigate the impacts of two social systems - guild system and friends system - on user retention in massively multiplayer online role-playing games (MMORPG) by drawing on the prior literature on the motivating effects of social relatedness. We estimate the impacts of these systems by using 1,204 users' data and a stratified Cox Proportional Hazard model. We found that while both systems positively affect user retention, the impact of guild system is stronger than that of friends system. This result contributes to the literature on social interaction and user retention in online games.

2 - The Impact of Information Technology on Firm Costs

Vaarun Vijairaghavan, University of Calgary, 2500 University Drive NW, Calgary, AB, T2N 1N4, Canada, vvijaira@ucalgary.ca, Barrie R. Nault

We evaluate the mechanics of IT productivity, by analyzing the channels through which IT improves firm productivity. Viewing firm productivity as a standard Cobb-Douglas function, we disentangle the effects of IT on each of the major cost components of a firm. Our theoretical contribution is the development of a Cobb-Douglas based methodology to analyze the effect of IT investments on firm-reported costs.

3 - Coopetition in Ride Sharing Economy

Chenglong Zhang, PhD Candidate, University of Texas at Dallas, Richardson, TX, United States, Chenglong.Zhang@utdallas.edu, Jianqing Chen, Srinivasan Raghunathan

Ride sharing platforms (e.g., Uber, Lyft) face great uncertainties on supply side (drivers). Given the vehicle issue faced by drivers, ride sharing platforms cooperate with rental firms (e.g., Hertz) in order for potential drivers accessing vehicles. Given the competition for riders between the platform and the rental firm, we study their incentives to engage in such coopetition (competition and cooperation) relationship. We find that the cooperation on supply side intensifies their competition on demand side. Although the intensified price competition always decreases total revenue of the two firms from riders, cost reduction from the cooperation could dominate the effect of reduced revenue.

4 - Interdependence of IT investment in Supply Chains

Fengmei Gong, University of La Verne, La Verne, CA, 91750, United States, fgong@laverne.edu, Zhuo (June) Cheng, Barrie R. Nault, David Zhang

Information technology (IT), being the enabler of the supply chain integration, requires mutual investment from the business partners and can't be adopted or used unilaterally. As supply chain partners invest in IT, firms need to make similar investments in order to better collaborate with their partners. The purpose of this paper is to investigate the interdependence of IT investment in the supply chain networks at the industry level. We identify the supply chain networks by utilizing the industry level input-output tables. Spatial econometrics methodology is used as the estimation technique to estimate the influence of supply chain neighbors on each other's IT investment.

■ MA29

CC- Room 4C-4

Procurement Design

Sponsored: Auction and Market Design

Sponsored Session

Chair: Nicolas Fugger, Mannheim, 68161, Germany

1 - The Role of Commitment in Auctions

Philippe Gillen, ZEW Mannheim, L7,1, Mannheim, 68161, Germany, gillen@zew.de

We study the role of commitment in a first-price auction environment. We devise a simple two stage model in which bidders first submit an initial offer that the auctioneer can observe and then makes a counter offer. There is no commitment on the auctioneer's side to accept an offer as is or even to choose the lowest bidder. We compare this setting to a standard first-price auction both theoretically and experimentally. While theory suggests a clear revenue ranking and a difference in bidding behavior, we cannot confirm these hypothesis in the experiment.

2 - Suppliers Cutting Corners: Can Excessive Competition Compromise Quality?

Aadhaar Chaturvedi, Assistant Professor, University of Namur, Namur, Belgium, aadhaar.chaturvedi@unamur.be

Supplier(s) cutting corners by downgrading product quality is an ever present problem for a buyer. Product testing and supplier screening are typically limited in detecting it and penalties are non-credible for small entrant suppliers. We investigate the impact that increasing competition would have on supplier(s) decision to cut corners. We model a reverse auction in which the winning supplier(s) decides (ex-post) to cut corners and look at the impact that either number of participating bidders or dual sourcing (level of competition) would have on supplier(s) likelihood (ex-ante) to cut corners. We then characterize buyer's decision on the number of suppliers to invite and to dual source.

3 - Drug Procurement Auctions and Supply Uncertainty

Nicolas Fugger, ZEW Mannheim, L7, 1, Mannheim, 68161, Germany, Ulrich Laitenberger

Supply uncertainty because of shortages is a common problem in drug procurement auctions. Multi-unit auctions to contract multiple firms are a possible solution to decrease supply uncertainty. We use a theoretical model and data from generic drug procurement auctions by German health insurers to study the motives for offering multiple contracts and their effects on auction outcomes. Our model shows that increasing the number of contracts can at the same time decrease supply uncertainty and increase competitive pressure on bidders.

4 - Debarment and Collusion in Procurement Auctions

Yoan Hermstrüwer, Max Planck Institute for Research on Collective Goods, Bonn, Germany, hermstruewer@coll.mpg.de, Claudia Cerrone, Pedro Robalo

This paper explores the impact of debarment as a deterrent of collusion in first-price procurement auctions. We develop a procurement auction model where bidders can form bidding rings, and derive the bidding and collusive behavior under no sanction, debarment and fines. The model's predictions are tested in a lab experiment. We find that debarment and fines both reduce collusion and bids. The deterrent effect of debarment increases in its length. However, the debarment of colluding bidders reduces efficiency and increases the bids of non-debarred bidders. The latter suggests that the market size reduction resulting from debarment may trigger tacit collusion.

■ MA29a

CC- Room 400

Health Care, Modeling and Optimization V

Contributed Session

Chair: Mahboubeh Madadi, San Jose State University, College of Engineering and Science, Ruston, LA, 71272, United States

1 - Adjusting for Time Varying Confounding in Adaptive Interdisciplinary Pain Management Program

Ashkan Farahani, UT-Arlington, Arlington, TX, United States

Interdisciplinary pain management programs involve diverse medical professionals to administer a mix of analgesic and cognitive treatments to improve quality of life in patients suffering from chronic pain. The observational nature of the data along with treatments administered over time lead to time varying confounding between treatments and patient's state variables and pain outcomes. This induces bias in the state transition and outcome model employed in this framework. This presentation discusses the inverse probability of treatment weighting framework to address time varying confounding in estimating causal effects of treatments.

2 - Analysis on Coordination Mechanism of the Referral System between Healthcare Institutions with Different Hierarchy

Sen Yang, Southeast University, Nanjing, China, elvinyang_seu@126.com, Haiyan Wang

The demand for high quality medical resources in China leads to the imbalance of patients in the major hospitals and community healthcare centers. An effective referral system between major hospitals and community healthcare centers is one of the ways to solve this problem. We analyze the competitive equilibrium of different institutions under different objectives using an integrated model of queuing and game theory, considered the effects of different incentives on the choice of primary care institution. The result shows that the subsidy mechanism can effectively coordinate the referral system.

3 - The Strategy of Revenue Sharing in Two-way Referral Mechanism for Healthcare Alliances

Jie Deng, Jiangnan University, Wuxi, China, chiechteng@hotmail.com

Since the limited medical resources in China, establishing the healthcare alliance and developing the two-way referral mechanism have becoming the inevitable choice to promote the rational use of health resources and reducing the waiting time and cost of patients. The study develops an analytical framework for a revenue sharing mechanism between healthcare alliance, where tertiary hospitals and community hospitals retaining its own objective function, we investigated the revenue sharing under various scenarios and found when the agreement is more likely to reached, and its effects on balance their busy between the tertiary-community hospitals, and finally analyze its benefits for patients.

4 - Pain Management via Opiods: Incorporating Pain Sensitivity into Prescription Decisions

Abdullah H. Gokcinar, The University of Texas at Dallas, Richardson, TX, United States, abdullahhalit.gokcinar@utdallas.edu, Metin Cakanyildirim

Use of opioids in pain management constitutes a significant challenge in healthcare. Underprescription of opioids yields inadequate pain-relief, while overprescription leads to serious side effects. Furthermore, opioids can paradoxically induce even higher pain, rather than reducing it. These make correct prescription decisions vital and difficult to obtain. We study the optimum opioid-use decisions in an analytical (probabilistic) model under various prescription / treatment policies. To the best of our knowledge, this work is the first application of optimization theory to the pain management context, and provides us and medical professionals with a novel pain model.

5 - Adaptive Joint Scheduling and Vehicle Routing Problem for Community-based Healthcare Delivery

Samira Fazel Anvaryazdi, Washington University in Saint Louis, St. Louis, MO, 71270, United States, Mahboubeh Madadi

In this study, an adaptive joint scheduling and vehicle routing scheme is proposed for community-based healthcare delivery. The goal is to maximize community-level health outcomes over a finite time horizon. We seek to derive optimal policies to deliver care to heterogeneous patients (with varying risk factors) located in different regions. A mobile health clinic visits patients whose demand might be known a prior or stochastic.

■ MA30

CC- Room 6A

Tutorial: The Secrets of Machine Learning: Ten Things You Wish You Had Known Earlier to be More Effective at Data Analysis

Emerging Topic: Tutorials

1 - Tutorial - The Secrets of Machine Learning: Ten Things You Wish You Had Known Earlier to be More Effective at Data Analysis

Cynthia Rudin, Duke University, Durham, NC, 27708, United States, David Carlson

There is much more to machine learning than the current cloud of myth and hype surrounding it. Despite the widespread usage of machine learning throughout organizations, there are some key principles that are commonly missed. Our TutORial will help you see through this hype and understand these key principles. It is entitled "The Secrets of Machine Learning: Ten Things You Wish You Had Known Earlier to be More Effective at Data Analysis.

■ MA31

CC- Room 6B

Applications in the Handbook of Military and Defense Operations Research

Sponsored: Military and Security

Sponsored Session

Chair: Natalie M Scala, Towson University, Towson, MD, 21252, United States

Co-Chair: James P. Howard, Johns Hopkins Applied Physics Laboratory, Columbia, MD, 21045, United States

1 - Military Workforce Planning and Manpower Modeling

Nathaniel D. Bastian, Operations Research Scientist | Assistant Professo, Army Cyber Institute, U.S. Military Academy, West Point, NY, 10918, United States, nathaniel.bastian@westpoint.edu, Andrew Oscar Hall

Military workforce planning and manpower modeling employs operations research tools and techniques to address problems of creating jobs and positions, as well as finding and assigning people to these positions. We provide an overview of military workforce planning and manpower modeling as it pertains to the military operations research practitioner and researcher. We review previous work in the domain, and we describe the four main classes of operations research methods. We also discuss multi-disciplinary research supporting retention and talent management, along with two real-world case studies to highlight applications in practice.

2 - Threatcasting in a Military Setting

Natalie Vanatta, U.S. Army, Ft Meade, MD, United States, Brian D. Johnson

The intersection of digital and physical security is critical to the future security of our military and national defense. Coming technological advances widen the attack plain over the next decade enhancing vulnerabilities. Helping to understand and plan for the future operating environment is the basis of a research effort known as Threatcasting. This analytic technique focuses on the intersection between cyber and physical domains and how it can revolutionize or paralyze the future. This session will use the weaponization of artificial intelligence as a case study to explain the research technique and results.

3 - Simulation Optimization of a Missile Attack Plan

Brian M. Wade, Director, US Army TRADOC Analysis Center - Monterey, Monterey, CA, United States, brian.wade@nps.edu, Shane N. Hall, Benjamin G. Thengvall

This paper discusses the importance of simulation optimization in military applications, and a brief overview of the simulation optimization literature applied to military applications is also included. Next, a relevant, real-world military problem of planning ballistic and cruise missile plans to maximize damage to an airfield is presented. Simulation optimization using three discrete-event simulations and an optimization metaheuristic program is used to analyze and solve this military problem. Finally, solutions that trade-off runway damage with the destruction of aircraft and fuel sites are discussed.

■ MA32

CC- Room 6C

Daniel H. Wagner Prize I

Emerging Topic: Daniel H. Wagner Competition

Emerging Topic Session

1 - Daily Tutor Scheduling Support at Hopeful Journeys Educational Center

Matthew D. Bailey, Bucknell University, Freeman College of Management, Taylor Hall, Lewisburg, PA, 17837, United States, Lucas A. Waddell

Hopeful Journeys Educational Center is a non-profit school providing full-day one-on-one tutoring for students with autism. The hourly assignments of tutors to students are subject to numerous constraints and preference such as student need and availability, teacher availability, qualifications, and team assignments. Working closely with the school-wide scheduler and under a limited budget, we developed a cost-effective, optimization-based daily scheduling support system. The system has become an integral part of their scheduling process saving hours of work each day. In the course of its development and deployment, it provided some interesting modeling and computational challenges.

2 - Empowering Denver Public Schools System to Optimize School Bus Operations

Amanda Chu, Georgia Tech-ISYE, Atlanta, GA, 30332, United States, Pinar Keskinocak, Monica Villarreal

Over 25 million students take advantage of school bus services according to the U.S. National Center for Education Statistics. School bus transportation is an integral service to students and their families. This collaborative project between Denver Public Schools (DPS) and Georgia Tech focused on creating bus route assignments to minimize objectives such as buses used, lateness, and reposition miles. We incorporated models into a decision-support (DS) tool, which enables users to create and analyze school bus route assignments. The methods and tool have been successfully used by DPS routers and analysts in the 2018-2019 academic year resulting in positive impact across multiple dimensions.

3 - Pricing Analytics for Rotable Spare Parts

Adam N. Elmachtoub, Columbia University, New York, NY, United States, Omar Besbes, Yunjie Sun

We describe a comprehensive approach to pricing analytics for reusable resources in the context of rotable spare parts, which are parts that can be repeatedly repaired and resold. Pricing rotable spare parts presents unique challenges ranging from limited data availability, minimal demand information, and complex inventory dynamics. Working in collaboration with a major aircraft manufacturer, we develop a novel pricing analytics approach that tackles all of these challenges, and describe a large-scale implementation which resulted in 3.9% improvement in profit over a ten-month period.

■ MA33

CC- Room 602

Financial Engineering I

Contributed Session

Chair: Qi Zhao, University of Illinois-Urbana-Champaign, Champaign, IL, 61820, United States

1 - Cracking the Black Box: A Neural Network Based Option Valuation Model

Yi Cao, Lecturer in Management Science, University of Edinburgh, Edinburgh, United Kingdom, jason.caoyi@gmail.com, Xiaoquan Liu, Jia Zhai

We develop a novel hybrid gated neural network based option valuation model. We start from the no-arbitrage option pricing theory, design a multiplicative structured hidden layers to maintain its differentiability, and select the slope and weights of input layers to satisfy the constraints. A separate neural network is constructed for predicting implied volatility. By offering economic interpretation our model extends the machine learning literature that predominantly focuses on complex algorithms to enhance mapping performance. It also contributes to the option valuation literature by offering neural network based analytical Greek letters. Empirical evidences are on S&P 500 options.

2 - Systemic Risk Quantification via Shock Amplification in Financial Networks

Dohyun Ahn, The Chinese University of Hong Kong, Shatin, N.T., Hong Kong, dohyun.ahn@cuhk.edu.hk, Nan Chen, Kyoung-Kuk Kim

We focus on systemic risk quantification under the Eisenberg-Noe network model with random shocks. In particular, we address the issue of incomplete network information by characterizing shock amplification due to the network structure. We obtain robust bounds and asymptotic behaviors of default probabilities when only partial network information is available, and we observe that the link structure of the network contains crucial information. Furthermore, we apply these results to the computation of systemic risk capital and its robust version using chance-constrained optimization.

3 - Assessing the Value of Retrofitting Carbon Capture and Storage to Natural Gas-fired Power Plants

Liping Fang, Ryerson University, Toronto, ON, Canada, lfang@ryerson.ca, R.S. Elias, M.I.M. Wahab

A real-options approach to ascertain the value of retrofitting carbon capture and storage technology to existing natural gas-fired power plants is presented. A plant is valued based on clean spark spread options. Uncertainties of electricity and natural gas prices are modeled using mean-reverting processes. Two carbon capture and storage technologies, post-combustion and oxy-fuel combustion, are considered. Whether to retrofit and at what carbon price to retrofit are analyzed and sensitivity analyses based on different costs, prices, and volatility parameters are carried out.

4 - Top-down Valuation Framework for Employee Stock Options

Yang Zhou, University of Washington, Seattle, WA, United States, yzhou7@uw.edu, Tim Leung

We propose a new valuation framework for employee stock options (ESOs). Our approach accounts for vesting period, multiple early exercises, and sudden job termination. To compute the ESO costs, we develop several numerical methods to solve the associated systems of PDEs. We implement and compare different numerical methods, and examine the effects of various contractual features.

5 - Financial Distress Prediction in Colombian Infrastructure Firms Using Logistic Regression and Support Vector Machines

Carlos A. Caro, Universidad de los Andes, Bogotá, Colombia, ca.caro10@uniandes.edu.co

Bankruptcy describes the condition in which a business cannot repay their debts, which forces them to follow legal and financial liquidation processes. Bankruptcies incur severe consequences to shareholders, creditors, and employees. Advanced statistics and machine learning techniques have been used in the past years to predict many business failure cases. Such models have been of great use for investors, creditors, auditors, banks and government policymakers. In this study, logistic regression and support vector machine models are used with the aim of predicting the financial distress risk of firms belonging to the construction industry in Colombia, one-year prior of its occurrence.

6 - Empirical Study of Fractional Stochastic Volatility

Qi Zhao, University of Illinois, Urbana-Champaign, Urbana, IL, United States, qiz2@illinois.edu, Alexandra Chronopoulou

The Hurst index is a vital parameter in a fractional stochastic volatility model that determines whether the model is long-range dependent (exhibits long memory) or antipersistent (rough). In our work, using options data we extract the stock's volatility via a regression method which we then use to estimate the Hurst index by applying a variations-based semi-parametric technique. When the method is applied to an S&P 500 dataset, we compute the Hurst index to be around 0.18, and conclude that the volatility is rough.

■ MA34

CC- Room 603

Optimization and Randomness

Sponsored: Optimization/Global Optimization

Sponsored Session

Chair: Georgina Hall, INSEAD, Fontainebleau, 77300, France

1 - Partial Recovery in the Graph Alignment Problem

Georgina Hall, INSEAD, Boulevard de Constance, Fontainebleau, 77300, France

We consider two adjacency matrices A and B, obtained by generating two correlated (n,q,s) Erdos-Renyi graphs A1 and A2, and taking A=A1 and B=Pi^*TA2Pi^*, where Pi^* is a permutation matrix. We present conditions on n, q, and s under which one can recover, both theoretically and computationally, a permutation matrix whose overlap with Pi^* is larger than a fixed fraction of the nodes. We also present conditions on n, q and s under which recovery is impossible. Joint work with Laurent Massoulie.

2 - An Optimal-Storage Approach to Semidefinite Programming using Approximate Complementarity

Madeleine Udell, Assistant Professor, Cornell University, New York, Ithaca, NY, 14850, United States, udell@cornell.edu

This talk develops new storage-optimal algorithms that provably solve generic semidefinite programs (SDPs) in standard form. The methods are particularly effective for weakly constrained SDPs. The key idea is to formulate an approximate complementarity principle: Given an approximate solution to the dual SDP, the primal SDP has an approximate solution whose range is contained in the null space of the dual slack matrix. For weakly constrained SDPs, this null space has very low dimension, so this observation significantly reduces the search space for the primal solution.

3 - Achieving Acceleration in Distributed Stochastic Optimization

Mert Gurbuzbalaban, Rutgers University, 100 Rockafeller Rd, Piscataway, Piscataway, NJ, 08854, United States, mg1366@business.rutgers.edu

We study distributed stochastic multi-agent optimization problems defined over a network where each agent possesses a local cost function that is strongly convex and smooth where only stochastic estimates of the gradient are available. We show that a momentum variant of distributed stochastic gradient converges to a neighborhood of the optimum with the accelerated linear rate while being communication-wise efficient. Building on this result, we develop optimal stochastic gradient algorithms that can achieve the lower bounds up to log factors and illustrate their performance in practice.

4 - Towards understanding Random and Deterministic Order in ADMM and Coordinate Descent

Ruoyu Sun, University of Illinois Urbana-Champaign, Minneapolis, MN, 55414, United States

Since the recent finding that multi-block ADMM (Gauss-Seidel order) does not converge, people have found three variants of ADMM that converge in practice: Gaussian-back substitution ADMM (GBS-ADMM), symmetric Gauss-Seidel ADMM (sGS-ADMM), randomly permuted ADMM (RP-ADMM). The first two are deterministic, and the third is random. We prove that in the worst-case, the two deterministic orders can be O(n^2) times slower than randomized order for solving unconstrained problems. In addition, we show that for RP order the gap is at most O(n), based on the proof of a weak matrix AM-GM inequality.

■ MA35

CC- Room 604

Algorithmic Advances in Lot Sizing and Other Applied MIP Problems

Sponsored: Optimization/Integer and Discrete Optimization

Sponsored Session

Chair: Kartik Kulkarni, Blacksburg, VA, 24060, United States

Co-Chair: Manish Bansal, Virginia Tech., Blacksburg, VA, 24060, United States

1 - Optimization of Out-of-Hours Schedules for Pharmacies

Arie M. Koster, Professor of Discrete Optimization, RWTH Aachen University, Pontdriesch 14-16, Aachen, 52056, Germany, koster@math2.rwth-aachen.de, Christina Büsing, Timo Gersing

The supply of pharmaceuticals is a critical component of a functioning health care system. To guarantee a 24/7 supply, all pharmacies in Germany have to participate in an out-of-hours schedule. To minimize the total number of services, we simultaneously have to deal with covering, packing and coloring constraints. In this talk, we present an integer programming formulation to obtain a recurring schedule of services. Furthermore, combinatorial insights for the problem are derived from this model and computational results for real-life cases are presented.

2 - Recent Computational Advances for Solving the Multi-item Capacitated Lot-sizing Problem

Esra Buyuktahtakin Toy, Associate Professor, New Jersey Institute of Technology, Newark, NJ, United States, esratoy@njit.edu, Ning Liu, Cole Smith, Joseph C. Hartman

In this talk, we will review recent computational progress regarding the multi-item capacitated lot-sizing, which is a core production and inventory planning problem. Our approaches vary from DP-based and partial objective function inequalities to approximate dynamic programming in order to tackle this highly complex NP-hard problem in a tractable solution time.

3 - Improving Column Generation via Random Coloring and Parallelization for Vehicle Routing Problems

Miao Yu, University of Michigan, Ann Arbor, MI, United States, miaoyu@umich.edu, Viswanath Nagarajan, Siqian Shen

Vehicle routing problems arise in a variety of applications including the emerging shared-mobility-based pickup and delivery problem and home medical care delivery. We consider a VRP where each customer has a unit demand. To efficiently solve the pricing problem in the column generation, we propose two parallel algorithms for the elementary shortest path problem with resource constraints: an extension of the pulse algorithm first proposed by Lozano et al. and a random coloring algorithm based on the color-coding of Alon et al. We conduct numerical experiments to evaluate the proposed algorithms on classic VRP benchmark, as well as instances of medical home care delivery problem.

4 - Exact Algorithms for Lot-sizing Problem with Multiple Capacities, Piecewise Concave Costs, and Subcontracting

Kartik Kulkarni, Virginia Tech, Blacksburg, VA, 24060, United States, kartikrf@vt.edu, Manish Bansal

We present an exact algorithm for a generalized lot-sizing problem with the following features: (a) the total production capacity in each time period is the summation of binary multiples of n capacities of different sizes, (b) subcontracting option; and (c) concave costs. We also study lot-sizing problem with piecewise concave production costs and concave holding costs. Our computational results show that these algorithms are computationally efficient.

■ MA36

CC- Room 605

Advance in Theory and Application of Optimization Under Uncertainty II

Sponsored: Optimization/Optimization Under Uncertainty

Sponsored Session

Chair: Ruiwei Jiang, University of Michigan, Ann Arbor, MI, 48109, United States

1 - A Reliable Facility Location Problem with Wasserstein Ambiguity Set

Kanglin Liu, Tsinghua University, Beijing, China, lkl15@mails.tsinghua.edu.cn, Ruiwei Jiang, Zhihai Zhang

Supply chain disruption will cost severe damgae to the entire system. To improve efficiency and effectiveness, we consider a reliable uncapacitated facility location problem, where the probability of facility failure lives in a Wasserstein ball centered at the empirical disruption distribution. The original distributionally robust model is formulated as a two-stage stochastic program with the objective of minimizing fixed cost and worst-case expected transportation cost. We reformulate the original min-max-min problem as an entire minimization linear program by proving totally unimodularity.

2 - Stochastic Optimization of Unimodular Functions

Lawrence Thul, Graduate Student, Princeton University, Princeton, NJ, United States, lathul@princeton.edu, Warren Powell

We propose a derivative-free method for optimizing a stochastic unimodular function in a finite, one-dimensional domain. In nonconvex stochastic optimization problems, stepsize tuning can be one of the most challenging and time consuming tasks. This stochastic line search method can be applicable to solving for the best stepsize in each iteration of gradient descent on stochastic functions.

3 - Geometric Evaluation of Robustness of Stochastic Optimization Solutions

Jorge Vera, Professor, Pontificia Universidad Catolica de Chile, Dept. Industrial and System Engineering, Universidad Catolica de Chile, Santiago, 7820436, Chile, jvera@ing.puc.cl

2-stage models attempt to make "good" decisions, considering the impact of those decisions in an uncertain future using the expected cost of the second stage as a measure of that impact. In this work we explore the effect of first stage decisions on the geometry of the optimization problem of the second stage. A problem with good geometry might be less sensible to perturbations in the data and, hence, more robust to the risk of uncertainty. We show how to formulate a 2-stage problem that tries to optimize the balance between cost and a suitable geometric measure of the second stage and illustrate the idea in some simulated experiments as well as a real industrial application.

4 - Distributionally Robust Combinatorial Optimization

Ruiwei Jiang, University of Michigan, Ann Arbor, MI, 48109, United States, ruiwei@umich.edu, Shabbir Ahmed, Mohit Singh

We study distributionally robust analogs of combinatorial optimization problem with uncertain objective coefficients. We provide equivalent deterministic reformulations of such problems under several types of ambiguity sets, and discuss corresponding solution approaches.

5 - Efficient Algorithms for Discrete Distributionally Robust Stochastic Program

Zhe Zhang, Georgia Tech, Atlanta, GA, 30318, United States, Shabbir Ahmed, Guanghui Lan

Recently, there has been a growing interest in distributionally robust optimization as a principled approach to data-driven optimization. In this paper, we consider the two-stage distributionally robust stochastic program with discrete scenario support. For continuous scenario support problem, while much research effort has been devoted to exact tractable reformulations, but one often has to resort to solving a discretized approximation when such reformulations are unavailable. Despite the problem's importance, few algorithms are developed, and most of them can neither handle the non-smooth second stage cost function nor the large number of scenarios K effectively. We fill the gap by developing two O(1/epsilon) algorithms whose iteration complexity only mildly depend on K. Moreover, the major computations involved in each iteration of these algorithms can be conducted in parallel if necessary. Finally, for the most important Kantorvich ball ambiguity set, we propose a slight modification of our algorithms to overcome the demanding computation of the distribution projection.

■ MA37

CC- Room 606

Data Driven Optimization and Applications

Sponsored: Optimization/Optimization Under Uncertainty

Sponsored Session

Chair: Andrew Lim, National University of Singapore, Singapore, 119245, Singapore

1 - A Robust Approach to Uncertainty in Games with Applications to a Cournot Model

Giovanni P. Crespi, Professor, Universita' degli studi dell'Insubria, Varese, Italy, giovanni.crespi@uninsubria.it, Matteo Rocca, Davide Radi

Introducing uncertainty and ambiguity averse players on a game, we study the notion of robust-optimization equilibria (ROE), proving they can be represented as Nash equilibria of a "nominal" game. We provide deeper insight in the notion of -Nash Equilibria, as a characterization of ROE and we show the ROEs may be qualitatively different from Nash-Equilibria in the nominal counterpart. For example, multiple and asymmetric ROEs can exist for a robust game such that its nominal counterpart is a simple symmetric game with only a symmetric Nash-equilibrium. With a learning mechanism in a duopoly game, we show also the convergence properties to an equilibrium differ.

2 - Enhance Principal Components Analysis by Using the Most Robust Solution as the Groundwork

Long Zhao, National University of Singapore, CBA 5.334 B, Singapore, 78712-1277, Singapore, Rui Gao

Instead of carefully designing uncertainty sets, we propose a new way to utilize RO or DRO to obtain a fantastic on-average performance. We take the most robust solution, i.e., the solution with infinity size uncertainty set, as the groundwork and use the well-estimated information to build upon it. To showcase the power of this simple idea, we apply it to enhance the PCA because the top PCs are good estimations. Although the new method uses a much fewer number of PCs, it can at least matches the best possible PCA method across all datasets we tried with five different objectives. We also provide theoretical evidence and simulation results to show the importance of the most robust solution.

3 - Forecasting Demand for New Products

Shanshan Huang, National University of Singapore, National University of Singapore, BIZ2 B1-01, Singapore, 117592, Singapore, shanshanhuang@u.nus.edu, Andrew Lim, Tong Wang

We develop an innovative forecasting methodology for estimating the demand for new products. The key challenge is that there are no historical sales for new products. One approach is to fit a regression or machine learning method to the sales and covariates data for existing products. However, it ignores the key substitution effects. We develop a blending of choice models to account for potential substitution patterns. Our method reduces the prediction error by 50% compared to benchmarks such as regression and machine learning methods.

4 - Approximating the Gittins Index in a Bayesian Bandit

Andrew Lim, National University of Singapore, 15 Kent Ridge Drive, Mochtar Riady Building, Singapore, 119245, Singapore, andrewlim@nus.edu.sg

While the optimal policy for the Gittins-Whittle formulation of the multi-armed bandit is fully characterized in terms of the Gittins index, the Gittins index is notoriously difficult to compute for high dimensional Bayesian bandits. We develop a method for approximating the dynamics of the posterior and show how it can be used to approximate the Gittins index for high-dimensional Bayesian bandits. Comparisons of the Gittins-Whittle framework to Thompson sampling and the Upper Confidence Bound approach will be discussed, and applications of our approximation to Bayesian bandits where the rewards are mixtures will also be presented.

■ MA38

CC- Room 607

Advances in Sequential Decision-Making Algorithms

Sponsored: Optimization/Optimization Under Uncertainty

Sponsored Session

Chair: Daniel Jiang, University of Pittsburgh, Pittsburgh, PA, 15261, United States

1 - Lookahead-bounded Q-learning

Ibrahim El Shar, PhD Student, University of Pittsburgh, Pittsburgh, PA, United States, ije8@pitt.edu, Daniel Jiang

Lookahead-bounded Q-learning (LBQL) introduced in this work is a new convergent variant of Q-learning which addresses the problem of sample efficiency in the standard Q-learning algorithm. LBQL uses the collected experience and the current action-values as a Q-based dual feasible penalty to create the so-called information relaxation dual dynamic programs. These are then used to enhance the performance of the standard Q-learning algorithm by providing lower and upper bounds on its iterates. We show that LBQL converges to the optimum action-values with probability 1. Numerical experiments confirm the quick convergence of LBQL as compared to standard Q-learning algorithm.

2 - New Empirical Algorithms and Convergence Analysis for Approximate Dynamic Programming

William Haskell, Purdue University, West Lafayette, IN, 01945, United States

In this talk, we consider empirical methods for doing large-scale dynamic programming that we call ‘empirical dynamic programming’ (EDP). EDP is easily implementable, and naturally supports function approximation for handling large or continuous state spaces. Our convergence analysis of EDP is based on iteration of random operators. As one of our key contributions, we develop a new method for convergence analysis of iteration of random operators, and we show that this method has broad applicability to many types of approximate dynamic programming algorithms. We also demonstrate the favorable performance of EDP in numerical tests.

3 - Leveraging Networks in Approximate Linear Programming

Selvaprabu Nadarajah, College of Business, University of Illinois at Chicago, Chicago, IL, 60607, United States, selvan@uic.edu, Andre Augusto Cire

We consider a hierarchy of approximate linear programs (ALPs) for solving a general class of discrete optimization problems based on network approximations of a value function. We show how the burden of solving these network ALPs can be overcome by restricting their feasible set using a construction that leverages chordal graphs. Our network ALPs and their restrictions have quality guarantees and exhibit promising performance on two challenging applications.

4 - Feedback-based Tree Search for Reinforcement Learning

Daniel Jiang, University of Pittsburgh, Pittsburgh, PA, 15261, United States, drjiang@pitt.edu, Emmanuel Ekwedike, Han Liu

Inspired by recent successes of Monte-Carlo tree search (MCTS) in a number of application domains, we propose a reinforcement learning (RL) technique that iteratively applies MCTS on batches of small, finite-horizon versions of the original infinite-horizon Markov decision process. The terminal condition of the finite-horizon problems, or the leaf-node evaluator of the decision tree generated by MCTS, is specified using a combination of an estimated value function and an estimated policy function. The recommendations generated by the MCTS procedure are then provided as feedback in order to refine, through classification and regression, the leaf-node evaluator for the next iteration.

■ MA39

CC- Room 608

Joint Session RAS/Practice Curated: Precision Scheduled Railroading

Sponsored: Railway Applications

Sponsored Session

Chair: Carl D. Van Dyke, TransNetOpt, West Windsor, NJ, 08550, United States

1 - Principles of Precision Scheduled Railroading

David T. Hunt, Director, Oliver Wyman, One University Square, Suite 100, Princeton, NJ, 08540, United States, david.hunt@oliverwyman.com

Shippers are tightening supply chains by continually demanding faster and more reliable transportation. To better adapt in this highly competitive environment, railroads are implementing Precision Schedule Railroading (PSR). This presentation will provide an overview of PSR, including why PSR is necessary to railroad operations today, what are the pros and cons of PSR, and how operations research and analytics can better enable successful PSR operations.

2 - Precision Scheduled Railroading at Norfolk Southern: Overall Process and Optimization Tools

Clark Cheng, Sr. Director Operations Res & Chief Data Scientist, Norfolk Southern Corporation, 3 Commercial Place, Atlanta, GA, 23510, United States, Clark.Cheng@nscorp.com, Yudi Pranoto

Norfolk Southern has adopted the precision scheduled railroading (PSR) principles as it develops new operating plan, TOP21. In this talk, we will first describe the overall process, and then focus on how OR models, including both simulation and optimization, have been leveraged to support this process.

3 - Precision Scheduled Railroading at CSX

Michael Swain, CSX. Transportation, 500 Water Street, 13th Floor - J300, Jacksonville, FL, 32202, United States

Scheduled railroading is transforming CSX into a more efficient and reliable railroad. Based on five guiding principles — safety, service, cost control, asset utilization and people — scheduled railroading is both an operating model and a shared commitment to excellence. We will discuss the various aspects of PSR and what they mean at CSX.

4 - Role of OR, Modeling and Analytics in Precision Scheduled Railroading

Carl D. Van Dyke, TransNetOpt, 6 Snowbird Court, West Windsor, NJ, 08550, United States, carl@cvdzone.com

Precision scheduled railroading (PSR) is viewed as a management strategy for getting the most out of a freight railway. These results are generally observed in metrics such as increased asset velocity, better on-time performance of shipments, reduced loco fleet sizes, higher service reliability, etc. Associated with this is a shift in how cars are handled, the roles of specific yards, and a rethink of the capital investment process. While much of this is often achieved through “smart railroading,” analytics, modelling and OR can play a key role to test the impact of potential changes, identify opportunities, and monitor system performance, all of which will be explored in this talk.

■ MA40

CC- Room 609

Optimization in Machine Learning: Accelerated Methods and Stochastic Optimization

Sponsored: Optimization/Nonlinear Programming

Sponsored Session

Chair: Alireza Fallah, Massachusetts Institute of Technology, Cambridge, MA, 02139, United States

Co-Chair: Asuman Ozdaglar, Massachusetts Institute of Technology, Cambridge, MA, 02139, United States

1 - On Acceleration with Noise-corrupted Gradients

Jelena Diakonikolas, University of California-Berkeley, University of California-Berkeley, 475 Evans Hall, Berkeley, CA, 94720, United States, Michael B. Cohen, Lorenzo Orecchia

We study the stability of accelerated algorithms in the setting of noise-corrupted gradients and provide two main technical contributions: (i) a new accelerated method AGD+ that generalizes Nesterov’s AGD and improves on the recent method AXGD, and (ii) a theoretical study of accelerated algorithms under noisy and inexact gradient oracles. This study leverages the simplicity of AGD+ and its analysis to clarify the interaction between noise and acceleration and to suggest modifications to the algorithm that reduce the mean and variance of the error incurred due to the gradient noise.

2 - A Universally Optimal Multistage Accelerated Stochastic Gradient Method

Alireza Fallah, Massachusetts Institute of Technology, Cambridge, MA, 02139, United States, afallah@mit.edu, Necdet Serhat Aybat, Mert Gurbuzbalaban, Asuman Ozdaglar

We study the problem of minimizing a strongly convex and smooth function when we have noisy estimates of its gradient. We propose a novel multistage accelerated algorithm that is universally optimal in the sense that it achieves the optimal rate both in the deterministic and stochastic case and operates without knowledge of noise characteristics. The algorithm consists of stages that use a stochastic version of Nesterov’s accelerated algorithm with a specific restart and parameters selected to achieve the fastest reduction in the bias-variance terms in the convergence rate bounds.

3 - A Unified Approach to Algorithm Analysis

Laurent Lessard, University of Wisconsin-Madison, Madison, WI, United States, laurent.lessard@wisc.edu

Even within the family of first order methods, there is tremendous variety. These include fast/accelerated methods, operator-splitting methods, proximal variants, quasi-newton methods, and more. This talk will present a unified control-theoretic framework for representing and analyzing algorithms. Algorithms are viewed as interconnections of simple components (linear dynamical systems, random noise, or adversarial disturbances), which allows us to leverage tools from robust and nonlinear control. In particular, we can derive bounds on worst-case convergence rates in an automated fashion, which leads to a natural energy dissipation interpretation and an associated Lyapunov function.

4 - Bregman Augmented Lagrangian Method and its Acceleration

Niao He, University of Illinois Urbana-Champaign, Urbana, IL, 61801, United States, niaohe@illinois.edu

We study a family of Bregman proximal augmented Lagrangian methods to solve linearly constrained convex optimization problems. The algorithm includes the classical method of multipliers as a special case. By exploiting the domain knowledge and special structures of the dual problem, it could lead to easier sub-problems. We establish convergence rates of the algorithm in the general convex and strongly convex settings. We further demonstrate how the algorithm can be applied problems related to Markov decision processes, and reveal connections with existing reinforcement learning algorithms.

■ MA41

CC- Room 610

Conic Optimization II

Contributed Session

Chair: Michael Rotkowitz, University of Maryland, Dept. of ECE, A.V. Williams Bldg., College Park, MD, 20742, United States

1 - Working in Reverse: Inverse Optimization Methods for Pyomo in Online Settings

Stephanie Allen, University of Maryland, College Park, College Park, MD, United States

Two recent papers by Dong, Chen, & Zeng and Barmann, Martin, Pokutta, & Schneider extend work from the online convex optimization field to parameterize an objective function in real time, meaning that a researcher must attempt to parameterize the objective function as parameters in the feasible region change and as the observed optimal solution also changes. We create a Python class (with help from the Pyomo optimization package) with online capabilities to implement these methods for a subset of convex optimization problems. We plan to use the class to replicate computational experiments from the papers.

2 - Discrete Choice Prox Functions on the Simplex

Vladimir Shikhman, Chemnitz University of Technology, Reichenhainer Str. 41, Chemnitz, 09119, Germany, vladimir.shikhman@mathematik.tu-chemnitz.de, David Müller, Yurii Nesterov

We derive new prox-functions on the simplex from additive random utility models of discrete choice. They are convex conjugates of the corresponding surplus functions. We explicitly derive the convexity parameter of discrete choice prox-functions associated with generalized extreme value models, and specifically with generalized nested logit models. Incorporated into subgradient schemes, discrete choice prox-functions lead to natural probabilistic interpretations of the iteration steps. As illustration we discuss an economic application of discrete choice prox-functions in consumption cycle.

3 - Upper Bounds for the Minimization of a Particular Singular Value

Michael C. Rotkowitz, Lyft, San Francisco, CA, United States, University of Maryland, College Park, MD, United States

We consider the problem of minimizing a particular singular value of a matrix variable, neither the largest nor the smallest, which is then subject to some convex constraints. This arises in the computation of the controllability of decentralized systems, and similar issues arise for vector order statistics. In this talk, we discuss the relatively easier issue of finding upper bounds for this problem. Some counter-intuitive results are presented on the best convex heuristic for this problem from a family of Ky Fan norms. We further show how expressing the singular value as a difference of Ky Fan norms, and using semidefinite representations of each, can be used to derive sequential convex procedures.

4 - Lower Bounds for the Minimization of a Particular Singular Value

Michael C. Rotkowitz, Lyft, San Francisco, CA, United States, University of Maryland, College Park, MD, United States

We consider the problem of minimizing a particular singular value of a matrix variable, neither the largest nor the smallest, which is then subject to some convex constraints. This arises in the computation of the controllability of decentralized systems, and similar issues arise for vector order statistics. In this talk, we discuss the more difficult issue of finding lower bounds for this problem. We discuss the formulation of the problem as a polynomial optimization (PO), such that sum-of-squares (SOS) techniques can be used to determine lower bounds. We further show how the Courant-Fischer characterization of the singular value can be used to derive a sampling technique to produce much smaller POs.

■ MA42

CC- Room 611

Challenges in Energy Systems Network Optimization

Sponsored: Optimization/Network Optimization

Sponsored Session

Chair: Kory Hedman

1 - Simulated Coordinated Scheduling and Operation of Electric and Natural Gas Networks

Aleksandr Rudkevich, President, Newton Energy Group LLC, Boston, MA, United States, Anatoly Zlotnik, Evgeniy Goldis, Russ Philbrick, Pablo Ruiz, Aleksandr Beylin, Xindi Li, Richard D. Tabors, Rafael Castro

We simulate a concurrent operation of the electric and natural gas networks. Electric network is modeled by a rolling horizon multi-cycle MIP-based SCUC and SCED optimization emulating day-ahead and real-time markets. A rolling horizon transient optimization of compressors and gas flows is used to clear the intra-day market on a pipeline network. Gas-fired generators are represented as gas and electric market participants. Coordination of gas and electric scheduling is achieved through the exchange of shadow prices, physical requirements and limitations between two markets. We present results comparing alternative coordination mechanisms using data for real markets in the Northeaster US.

2 - Challenges and Successes of Large Scale Power Network Optimization in Julia

Carleton Coffrin, Los Alamos National Laboratory, Los Alamos, NM, United States

The recent programming language Julia promises to combine the simplicity of high-level languages like python and Matlab with the performance of low-level languages like C and C++. If successful in its ambitions, Julia would drastically reduce the time required to transform prototype algorithms into production solutions. In this work we explore the viability of using Julia for solving large-scale non-convex mixed-integer optimization problems faced by power network operators, such as security-constrained optimal power flow. The underlying computational challenges are presented and the performance of Julia-based algorithms are compared to established high-performance alternatives.

3 - Optimization-based Approaches to Spatial Disaggregation of Virtual Batteries Over Power Networks

Mads R. Almassalkhi, University of Vermont, Burlington, VT, United States, malmassa@uvm.edu

Distributed energy resources (DERs) are often aggregated and coordinated as a single bulk resource or virtual battery (VB) that interfaces directly with market-based signals. However, a VB is often not aware of the physical location of the underlying DERs in the power network. This means that VB dispatch signals can lead to violations of local network limits, which can reduce grid reliability. This talk discusses recent convex optimization-based approaches to disaggregate a VB dispatch signal over an AC power networks to ensure network-admissible coordination of DERs during dynamic operating conditions.

4 - Large-scale Grid Models: Synthetic Data & Co-simulation

Bryan Palmintier, NREL, Golden, CO, United States, Tarek Elgindy

Power grid modernization and wide-spread distributed energy resource (DER) integration are driving an explosion of interest in advanced algorithms and new optimization schemes. However, there has historically been a lack of open-access realistically sized and detailed datasets—particularly for the distribution system—and simulation tools able to model these systems. This talk will present recent advances with very large-scale (>>1M nodes) distribution data sets and the use of co-simulation to tractably model large integrated transmission-distribution grids and their interactions with new controls/optimization.

5 - Challenges with Distributed Energy Resource Aggregation

Yonghong Chen, Consulting Advisor, MISO, Carmel, IN, United States, ychen@misoenergy.org

Distributed energy resources can potentially introduce significant challenges on market design and market operations. This talk will discuss several MISO R&D studies on DER modeling and integration. First of all, large amount of small resources can introduce significant computational challenges. Secondly, DER aggregation across multiple locations may introduce dispatch and pricing issues and the possibility of oscillation. It'll also require coordination between transmission and distribution. Thirdly, both participants and system operators will require better tools and processes to manage uncertainties.

■ MA43

CC- Room 612

Recent Advances in Learning and Distributionally Robust Optimization I

Sponsored: Computing

Sponsored Session

Chair: Hamed Rahimian, Northwestern University, Evanston, IL, 60208, United States

1 - Wasserstein Distributional Robustness, Regularization, and Generalization

Rui Gao, University of Texas at Austin, Austin, TX, 78712, United States, rgao32@gmail.com

In this talk, we consider Wasserstein distributionally robust optimization that aims to find a solution that hedges against a set of distributions that are close to some nominal distribution in Wasserstein metric. We discuss the connection between this framework and regularization problems in statistical learning, and study its generalization error bound.

2 - Distributionally Robust Reformulations of Discrete Probability Distributions

Ihsan Yanikoglu, Ozyegin University, Istanbul, Turkey, ihsan.yanikoglu@ozyegin.edu.tr

This talk focuses on robust reformulations of ambiguous chance constraints when the underlying family of distributions is discrete and supported in a so-called ``p-box”, ``p-ellipsoidal”, or phi-divergence uncertainty set. Using the robust optimization paradigm, the deterministic counterparts of the ambiguous chance constraints are reformulated as mixed-integer or convex optimization problems which can be tackled by commercial solvers for moderate sized instances. For larger sized instances, we propose a safe approximation algorithm that is computationally efficient and yields high quality solutions.

3 - Efficient Algorithms for Distributionally Robust Machine Learning

Soumyadip Ghosh, IBM TJ Watson Research Center, Yorktown Heights, NY, 10598, United States, ghoshs@us.ibm.com, Mark S. Squillante

We consider a new stochastic gradient descent algorithm for efficiently solving general min-max optimization problems that arise naturally in distributionally robust learning. By focusing on the entire dataset, current approaches do not scale well. We address this issue by initially focusing on a subset of the data and progressively increasing this support to statistically cover the entire dataset.

5 - Prescriptive Static Stochastic Programming

Hamed Rahimian, Postdoctoral Fellow, Northwestern University, Evanston, IL, 60208, United States, hamed@northwestern.edu, Bernardo Kulnig Pagnoncelli

Classical stochastic programming models (e.g., two-stage stochastic program and chance-constrained program) are often described by the random parameters. However, in many settings, random parameters depend on multidimensional features. We study stochastic programming models to prescribe an optimal decision in a framework that the random parameters need to be learned from a set of data. We demonstrate our framework using a variety of kernel smoothing functions, borrowed from the statistical learning, and we show the convergence properties of the resulting models. We also compare the results with the classical models that ignore the features information.

■ MA44

CC- Room 613

Navigating the Review Process – Recently Accepted Papers in Empirical Healthcare OM

Sponsored: Manufacturing & Service Oper. Mgmt/Healthcare Operations

Sponsored Session

Chair: Fernanda Bravo, UCLA Anderson School of Management, Los Angeles, CA, 90024, United States

Co-Chair: Song-Hee Kim, University of Southern California, Los Angeles, CA, 90089, United States

1 - Separate and Concentrate: Accounting for Patient Complexity in General Hospitals

Sandra Sülz, Erasmus University Rotterdam, Rotterdam, Netherlands, sulz@eshpm.eur.nl, Ludwig M. Kuntz, Stefan Scholtes

Scholars have recently suggested the reorganization of general hospitals into organizationally separate divisions for routine and non-routine services. We provide empirical evidence for this proposal from a quality perspective. Disentangling the effects of high absolute and relative hospital volumes in a disease group, our analysis suggests that both routine and complex patients would benefit from a hospital with a multi-specialty hub for emergency and non-routine elective services at its core, complemented by separate disease-focused hospitals-within-hospitals for routine services, and by adopting a disease-based departmental routing strategy for newly arriving complex patients.

2 - Using Patient-Centric Quality Information to Unlock Hidden Health Care Capabilities

Wallace J. Hopp, University of Michigan, Herrick Professor of Business, Ross School of Business, Ann Arbor, MI, 48109-1234, United States, Guihua Wang, Jun Li

We use mitral valve surgery outcome data to compute patient-centric information and evaluate the potential health benefits from using the information to guide patients to surgeons. We estimate total societal benefits from using patient-centric information are comparable to those achievable by enabling the best surgeons to treat 10-40% more patients.

3 - The Impact of Delay Announcements on Hospital Network Coordination and Waiting Times

Jing Dong, Columbia University, New York, NY, 60208, United States, Elad Yom-Tov, Galit Bracha Yom-Tov

We investigate the impact of delay announcements on the coordination within hospital networks using a combination of empirical observations and numerical experiments. We offer empirical evidence that patients take delay information into account when choosing emergency service providers and that such information can help increase coordination in the network. Our numerical results indicate that the level of coordination that can be achieved is limited by the patients’ sensitivity to waiting, the load of the system, the heterogeneity among hospitals and, importantly, the method hospitals use to estimate delays.

4 - Patient Prioritization in Emergency Department Triage Systems: an Empirical Study of the Canadian Triage and Acuity Scale (ctas)

Eric Park, University of Hong Kong, Hong Kong, ericpark@hku.hk, Yichuan Ding, Mahesh Nagarajan, Eric Grafstein

Emergency departments (EDs) typically use a triage system to classify patients into priority levels. Most triage systems do not specify how exactly to route patients across and within the assigned triage levels. Decision makers in EDs often have to use their own discretion to route patients. Also, how patient waiting is perceived and accounted for in ED operations is not clearly understood. Using patient-level ED visit data from 4 EDs in the metro Vancouver, BC, area, we structurally estimate the waiting cost structure of ED patients as perceived by the decision makers who make ED patient routing decisions. We derive policy implications and make suggestions for improving triage systems.

■ MA45

CC- Room 614

Distributed Optimization for Machine Learning

Sponsored: Optimization/Nonlinear Programming

Sponsored Session

Chair: Mert Gurbuzbalaban, Rutgers University, Piscataway, NJ, 08854, United States

Co-Chair: Bugra Can, Rutgers University, Newark, NJ, 07102, United States

1 - GNSD: A Gradient based Nonconvex Stochastic Algorithm for Decentralized Optimization

Mingyi Hong, University of Minnesota, Keller Hall, Minneapolis, MN, 55455, United States, Songtao Lu, Haoran Sun

In this paper, we propose a gradient-tracking based nonconvex stochastic decentralized (GNSD) algorithm for solving nonconvex optimization problems, where the data is partitioned into multiple parts and processed by the local computational resource. Through exchanging the parameters at each node over a network, GNSD is able to find the first-order stationary points (FOSP) efficiently. From the theoretical analysis, it is guaranteed that the convergence rate of GNSD to FOSPs matches the well-known convergence rate O(1/sqrt{T}) of stochastic gradient descent by shrinking the step-size.

2 - On Maintaining Linear Convergence of Distributed Learning and Optimization under Limited Communication

Na Li, Thomas D. Cabot Associate Professor, Harvard University, Cambridge, MA, 02138, United States, nali@seas.harvard.edu, Sindri Magnusson, Hossein Shokri Ghadikolaei

In parallel and distributed machine learning processors need to compress important algorithm information to bits so they can communicate and coordinate to solve large problems. We consider a general class of linearly convergent parallel/distributed algorithms and illustrate how we can design quantizers compressing the communicated information to few bits while still preserving the linear convergence. We illustrate our results on learning algorithms using different communication structures, such as decentralized algorithms where a single master coordinates information from many workers and fully distributed algorithms where only neighbors in a communication graph can communicate.

3 - An Inexact Penalty for Convex Problems with Linear Constraints

Angelia Nedich, ASU, Tempe, AZ, 85281, United States, Angelia.Nedich@asu.edu, Tatiana Tatarenko

In this work, we consider a constrained convex problem with linear inequalities and provide an inexact penalty re-formulation of the problem. The novelty is in the choice of the penalty functions, which are smooth and can induce a non-zero penalty over some points in feasible region of the original constrained problem. The resulting unconstrained penalized problem is parametrized by two penalty parameters which control the slope and the curvature of the penalty function. With a suitable selection of these penalty parameters, we show that the solutions of the resulting penalized unconstrained problem are feasible for the original constrained problem, under some assumptions.

4 - A Tight Convergence Analysis for Stochastic Gradient Descent with Delayed Updates

Yossi Arjevani, NYU, New York, NY, United States, yossi.arjevani@gmail.com, Ohad Shamir, Nathan Srebro

Gradient-based optimization methods are widely used in machine learning and other large-scale applications. However, in their standard formulation, they are also strongly synchronous in nature. In this work, we provide tight finite-time convergence bounds for stochastic gradient descent on quadratic functions, when the gradients are delayed and reflect iterates from a number of rounds ago. First, we show that without stochastic noise, delays strongly affect the attainable optimization error. In sharp contrast, we quantify how stochastic noise makes the effect of delays negligible, improving on previous work which only showed this phenomenon asymptotically or for much smaller delays.

5 - Decentralized Computation of Effective Resistances and Acceleration of Distributed Optimization Algorithms

Bugra Can, Rutgers University, Newark, NJ, 07102, United States, bc600@scarletmail.rutgers.edu

The effective resistance between a pair of nodes in a weighted undirected graph is defined as the potential difference induced between them when a unit current is injected at the first node and extracted at the second node. We develop an efficient provably linearly convergent distributed algorithm for computing effective resistances and use our algorithm to design an efficient communication matrix for consensus optimization. Our framework can accelerate many state-of-the-art distributed optimization algorithms including the EXTRA and DPGA methods on a variety of networks.

■ MA46

CC- Room 615

Network Models and Routing Algorithms I

Sponsored: Transportation Science & Logistics/Intelligent Transportation Systems (ITS)

Sponsored Session

Chair: Yufeng Zhang, University of Minnesota, Minneapolis, MN, 55455, United States

1 - Optimal Traffic Metering Locations and Levels in Urban Transportation Networks

Rasool Mohebifard, Washington State University, Pullman, WA, 99163, United States, Rasool.Mohebifard@wsu.edu, Ali Hajbabaie

Existing perimeter control methods regulate traffic flow at predefined gate locations. This study incorporates gate location decisions in perimeter control in an integrated Mixed-Integer Nonlinear Program (MINLP) and presents a customized methodology to solve it. The methodology divides the feasible region of the problem into several sub-regions based on gate locations, constructs two significantly less computationally complex MINLPs, decomposes them into primal and master problems, and finds solutions by solving them iteratively. Numerical analysis show that the integrated program reduces travel times by 8.5% to 8.8% compared to the case of perimeter control with fixed gate locations.

2 - A Linear Programming-based Algorithm for Traffic Assignment Problem with Link Interaction

Yufeng Zhang, University of Minnesota, Minneapolis, MN, 55455, United States, Alireza Khani

Traffic assignment algorithms play an important role in transportation-related studies. Classic traffic assignment algorithms set some restrictions on travel cost functions. We studied the traffic assignment problem for user equilibrium with link interactions and formulated it as Variational Inequalities. Using the Benders Decomposition technique, the problem was converted to a linear program and we further constructed the dual problem. We proposed an algorithm that only involves solving standard traffic assignment problems and linear programs for the problem. Some decent properties to the formulation were explored. Computational results were given to show the efficacy and efficiency of the algorithm.

3 - Learning Activities in Operations Research Course to Teach TSP and CVRP Problem

Evelyn Arrey, Universidad Catolica del Norte, Manuel Verbal 1333, Antofagasta, 1240000, Chile, evelyn.arrey@ucn.cl, Carlos Olivos, Hernan Caceres

We propose two learning activities in the course of Operations Research at Universidad Católica del Norte, Chile. The first one is focused in the Traveling Salesman Problem where the students have to represent it in a cork board using pins, and with a thread, they must determine the tour, using as little as possible. The other learning activity is based on the Capacitated Vehicle Routing Problem. The students must represent in real life the vehicle with capacity, and then they have to determine the best routes in order to minimize the attending cost to each demand point. With these activities, students learn about combinatorial complexity. Both activities will be presented to show the methodology results.

4 - Convergence Behavior for Network Characterization Metrics for Traffic Assignment

Priyadarshan Patil, University of Texas at Austin, Austin, TX, United States, Katherine Ross, Stephen Boyles

Traffic assignment (TA) is used for infrastructure planning, based on metrics like total system travel time (TSTT), vehicle miles traveled (VMT) or link flows. These metrics show different behaviors for a common network convergence state. This study presents formulations, computational analysis, and daily TA simulations for 14 networks at varying demands, comparing key metrics across convergence levels. Results show that VMT and TSTT stabilize far earlier (~1e-4 gap) than link flows (~1e-5), which stabilize slightly before used most likely path set and most likely path flows (~1e-6).

5 - Computational Performance of Constraint Programming for Routing Problems

Tiantian Zhu, Nanyang Technological University, 50 Nanyang Avenue, Singapore, 639798, Singapore, Stephen Boyles

Constraint programming (CP) has been applied to a variety of combinatorial optimization problems, most notably in scheduling applications. In other problems CP has also established itself as a competitor to state-of-art mixed-integer linear programming solvers. This work presents a comparison between these two approaches of their performance in solving routing problems, such as TSP, VRP and other variants of them. The paper explores the converging time and solution optimality of both approaches based on the test of numerous instances selected from the open-source TSPLIB and VRPLIB dataset.

■ MA47

CC- Room 616

Vehicle Routing II

Contributed Session

Chair: Wei Zhang, The Hong Kong Polytech University, MN037, Hung Hom, Hong Kong, China

1 - The Heuristic Algorithm for Etruck Traveling Salesman Problem with Battery Recuperation

Sungho Kang, Korea University, Seoul, Korea, Republic of, ght2game@korea.ac.kr, Taesu Cheong

When operating electric trucks, one of concerns is the limitation of the travel distance due to the limit of battery capacity. This issue can be relieved by the battery recuperation that is a technique of converting the position energy of the eTruck into the electric energy of the battery using the regenerative braking system. In this study, we study routing problem of eTruck with battery swapping stations and battery recuperation. This problem can be solved by replacing it with asymmetric TSP over energy TSP graph. This can be modeled by using a dynamic programming. However, due to the increased computational complexity, we propose a heuristic based methodology to address the concomitant problem.

2 - Determination of Optimum Irrigation Route for the Maintenance of Mine Roads

Camilo Gamboa, Universidad Catolica del Norte, Antofagasta, Chile

The unpaved routes of mine are extensive and cover a highly variable traffic flow. The maintenance management of these routes is carried out by a cargo vehicle, which stores a liquid mineral and irrigates all road networks to reduce the emission of dust into the environment. This management is carried out suboptimally since the irrigation process is carried out regularly throughout the system without preference or need criteria. The purpose of the work is to determine the network of optimal routes that the vehicle must travel to carry out irrigation in critical zones of high pollution rate, minimizing the costs of using liquid and fuel.

3 - Pricing Tax Return for Students that Opt-out from Using School Bus, the Case for Multiple Schools

Hernan Caceres, Department Chair, Universidad Catolica del Norte, Antofagasta, Chile, hcaceres@ucn.cl, Macarena Duran, Carlos Olivos, Rajan Batta

School districts are often mandated to provide transportation but can encounter ridership that varies between 22-72 percent. Consequently, buses run with unused capacity over long routes. We explore the scenario where students are compensated for giving up the option to ride a bus, to reduce the overall cost of the system. We explore the effect of applying either of two policies across all the schools of one district in Western New York. Mathematical formulations for this problem are developed and analyzed. Results from a case study along with algorithmic computational results will be presented.

4 - Dial-a-ride Problem with Floating Targets

Wei Zhang, The Hong Kong Polytechnic University, Kowloon, Hong Kong, wei.sz.zhang@connect.polyu.hk, Alexandre Jacquillat, Kai Wang, Shuaian Wang

This problem takes inputs as a batch of customer orders, each requesting travel from a given origin to a given destination by a given deadline. We optimizes sequences of stops visited by vehicles to pick up and drop off passengers. Unlike the traditional dial-a-ride problem, the pick-up locations can differ from the customers' origins, within a maximum walking distance. We determine the timings and the locations of the vehicle's stops, thus coordinating vehicle operations and customer pick-ups. We propose a mixed-integer second-order cone program with valid inequalities, and a dynamic programming-based algorithm to generate solutions in fast computational times.

■ MA48

CC- Room 617

Innovations in Urban Delivery

Sponsored: Transportation Science & Logistics/Freight Transportation & Logistics

Sponsored Session

Chair: Sara Reed, University of Iowa, Iowa City, IA, United States

1 - The Multi-visit Drone Routing Problem

Stefan Poikonen, University of Colorado Denver, Denver, CO, 80202, United States, Bruce L. Golden, Adriano Masone

The Multi-visit Drone Routing Problem is a truck-and-drone routing problem that seeks to minimize total route duration to service a predefined set of customers. In this problem, the energy dissipation rate of the drone is a user-defined function and the drone may be able to carry more than one package simultaneously. The definition of feasible locations to launch or retrieve a drone may be defined independently of the customer locations. We propose a heuristic that routes first, transforms the network graph second, and solves a shortest path thirdly. Extensions to launching along an edge may be presented.

2 - Last Mile Delivery using Autonomous Vehicles

Sara Reed, University of Iowa, University of Iowa, Iowa City, IA, United States, sara-j-reed@uiowa.edu, Ann Melissa Campbell, Barrett Thomas

An autonomous vehicle has the flexibility to remain in continuous use with or without the delivery person on board eliminating the need to park the vehicle. The Capacitated Autonomous Vehicle Assisted Delivery Problem (CAVADP) uses an autonomous vehicle as a mobile depot to support a delivery person in serving customers. We provide valid inequalities to the general model as well as results on general geographies of customers. We will show the value of using autonomous vehicles relative to standard delivery with parking.

3 - The Multiple Flying Sidekicks Traveling Salesman Problem with Variable Drone Speeds

Ritwik Raj, University at Buffalo, Amherst, NY, 14216, United States, r28@buffalo.edu, Chase Murray

This research studies the impact of unmanned aerial vehicle (UAV) speed in a system in which a truck combines with a fleet of UAVs for last-mile deliveries. Studies have shown that UAV power consumption increases nonlinearly with speed. Consequently, for a fixed battery capacity, UAV endurance decreases with speed. Also, depending on the parcel weight, the speeds at which UAVs can travel the maximum distance may vary. We leverage these properties to provide a three-phased algorithm that dynamically modifies speeds to achieve superior UAV performance, with the goal of minimizing the delivery makespan. Results indicate that total makespan can be decreased by operating UAVs at submaximal speeds.

4 - Splitting Shopping and Delivery Tasks in a Personal Shopper Service

Mathias A. Klapp, Assistant Professor, P. Universidad Catolica de Chile, Santiago, 7820436, Chile, maklapp@ing.puc.cl, Alp Arslan, Niels Agatz

We study an online personal shopper service, a type of last-mile delivery service operating as intermediary between customers and brick and mortar stores. This service receives and accepts orders dynamically over time, each defined by a list of items potentially required from multiple stores. For each accepted order, a shopper has to collect all items requested and deliver these to the customer location before a short deadline. We estimate the benefits of splitting customer requests into multiple tasks served by different shoppers in parallel and re-consolidating tasks of multiple requests having common collection points into one shopper.

■ MA49

CC- Room 618

On-demand Public Transit

Sponsored: Transportation Science & Logistics/Urban Transportation

Sponsored Session

Chair: Ankur Mani, University of Minnesota, Saint Louis, MO, 63108-2432, United States

Co-Chair: Varun Gupta

1 - A Markov-based Continuous Approximation Model for On-demand Public Transportation Systems

Alexander Vinel, Auburn University, Auburn, AL, 36832, United States, alexander.vinel@auburn.edu, Daniel F. Silva

We consider a family of models for on-demand public transportation systems that combine a continuous approximation approach with a Markov process. Our goal is to develop a simple way to evaluate system performance, which can then be used in capital planning (eg., fleet sizing, contracting, driver assignment, etc). We will present the analytical solution for the case of first- and last-mile operation. We then also demonstrate how this theoretical result compares with data collected from a real-world pilot project in a major US city.

2 - A Pricing Framework for the Multi-modal Mobility Marketplace

Ragavendran Gopalakrishnan, Assistant Professor, Queen's University, Department of Civil and Environmental Engg., Kingston, ON, 14853, Canada, Chamsi Hssaine, Siddhartha Banerjee, Samitha Samaranayake

We study the problem of designing an efficient mobility marketplace: a centralized platform where private on-demand mobility providers and public transit can jointly offer hybrid multi-modal trips to commuters. Pricing such trips to maximize social welfare, while ensuring that both commuters and mobility providers enjoy weak Pareto improvement (compared to the status quo), is a hard problem. Our general approach is based on formulating a "shaded" welfare maximization program and yields a pricing policy with a constant-factor approximation guarantee, under an intuitive structural condition based on a notion of the "efficiency gains" from introducing multi-modal trips.

3 - Dynamic on Demand Ride-sharing Trip-vehicle Matching with Pricing

Saeid Rasulkhani, New York University, New York, NY, United States, saeid@nyu.edu, Joseph Y.J. Chow

In this study we design a trip-vehicle matching problem for an on demand ridesharing systems. Using a stochastic process and stability principle, we define an online ticket pricing scheme for the system. A trip is set of pick up and drop off points of passengers with some feasibility constraints such as capacity and timing and so on. We match the trips to vehicles in a way that maximum payoff get generated. Once the matching problem is solved, the pricing ensures that none of passengers or drivers have incentive to deviate from their current matching pair.

4 - Integrated Optimization of Charging Facility Deployment and Vehicle Management for Electric Car-Sharing Systems

Yang Liu, National University of Singapore, Department of Industrial & Systems Engineering, Singapore, 117576, Singapore

Electric car-sharing systems are expected to be a promising alternative for sustainable urban mobility. We investigate an integrated optimization problem which determines the long-term facility deployment plan at the strategic level, while the operational decisions in the short term are also optimized. A two-stage stochastic integer program is formulated to capture the demand uncertainty, and a multi-layer time-space-battery network flow model is constructed for tracking battery states. We propose a two-phase benders decomposition algorithm. Numerical results reveal that the deployment of both fast charging and normal charging infrastructure can improve system performance.

■ MA50

CC- Room 619

Reliable Facility Location Against Disruptions

Sponsored: Transportation Science & Logistics/Facility Logistics

Sponsored Session

Chair: Xin Wang, University of Wisconsin-Madison, Middleton, WI, 53562-4278, United States

1 - Reliable Hub Location Model for Air Transportation Networks under Random Disruptions

Yong Liang, Tsinghua University, Beijing, China, Hao Shen, Zuo-Jun Max Shen

The popular hub-and-spoke network designs of major airlines can trigger cascading e ects under disruption events and lead to further losses. In this work, we present a path-based reliable hub location model that assigns to each origin-destination pair a primary path and a backup path to hedge against disruption risks. While most previous studies on reliable hub-and-spoke network design assume independent disruptions, our model allows disruptions to be correlated. We validate numerically the value of using backup paths, especially for inter-regional networks, where the results also demonstrate the importance of incorporating disruption correlations.

2 - Reliable Location of First Responder Stations for Cooperative Response to Disasters

Zhoutong Jiang, Master Student, University of Illinois at Urbana-Champaign, Champaign, IL, Champaign, United States, Yanfeng Ouyang

Major emergency incidents often require cooperative service from multiple types of responders; service effectiveness might suffer from probabilistic disruptions of the service stations themselves. We developed a reliable facility location model to optimally deploy emergency response resources such that the quality of emergency service (often from multiple jurisdictions) is maximized under the risk of disruptions. Numerical experiments are used to demonstrate the applicability of the model and to draw managerial insights.

3 - Emergency Power Planning for an Electric Transit System

Zhiwei Chen, University of South Florida, Tampa, FL, 33617, United States, zhiweic@mail.usf.edu, Xiaopeng Li

Transit systems have been through a transition to electric vehicle (EV) fleets. The main power charging system from the power grid may be disrupted during emergency and thus needs to be complemented by emergency power systems from alternative power systems (e.g., solar panels or generators). This study proposes a mathematical model for network planning of the emergency power system for an EV transit system.

■ MA51

CC- Room 620

Joint Session AAS/TSL Air: Air Traffic Flow Management

Sponsored: Aviation Applications

Sponsored Session

Chair: James Calvin Jones, MIT Lincoln Laboratory, Cambridge, MA, 02140, United States

1 - Assessing the Impact of Weather and Traffic Management Initiatives to the En Route Performance in the National Airspace System

Yulin Liu, University of California-Berkeley, University of California-Berkeley, Berkeley, CA, 94709, United States, Mark M. Hansen, Michael O. Ball, David J. Lovell

En route inefficiency is measured in terms of extra distance flown by aircraft, above the theoretical shortest distance route. We apply both trajectory clustering method and statistical models to quantify the impact of three major factors - convective weather, wind, and Traffic Management Initiatives (TMIs) including Miles-In-Trail (MIT) and Airspace Flow Program (AFP) - to the flight en route inefficiency. Statistical models indicate that weather is the most influential factor in seeming to cause flights to deviate from the great circle route. Winds and TMIs are also important for some origin-destination pairs, but less significant than convective weather.

2 - Rerouting Aircraft During Space Launches Using Adaptive Spatial Discretization

Rachael E. Tompa, Research Assistant, Stanford University, Stanford, CA, United States, Mykel John Kochenderfer

To ensure safety during space launches, the FAA restricts a large column of airspace that aircraft are rerouted around. With the increase of space launches, airlines are often penalized with rerouting expenses. Recent research has focused on making these restrictions smaller and dynamic. The problem has been modeled as a Markov decision process and solved using dynamic programming. A major challenge with this formulation is its computational tractability. This talk uses an adaptive spatial discretization method, to increase computational tractability while providing a finer state space discretization. This scalable method results in less disruption in the airspace while reducing risk.

3 - A Spectral Approach Towards Analyzing Air Traffic Network Disruptions

Max Z. Li, PhD Candidate, Massachusetts Institute of Technology, Cambridge, MA, 02140, United States, maxli@mit.edu, Karthik Gopalakrishnan, Kristyn Pantoja, Hamsa Balakrishnan

The networked nature of the air transportation system leads to system-wide delays due to disruptions at an airport. A comprehensive analysis of system performance requires understanding the inherent interdependencies between airports in order to characterize off-nominal disruptions and to aid in recovery. In this work, we apply Graph Signal Processing to the analysis of airport delay networks. We characterize different patterns of delay distributions using 10 years worth of operational data from major US airports. We show that attributes of the resultant eigenvector modes and energy contributions are useful metrics to characterize disruptions caused by specific off-nominal events.

4 - Reinforcement Methods for Air Traffic Management

James Jones, MIT Lincoln Laboratory, Cambridge, MA, 02140, United States, Yan Glina, Kendrick Cancio

In this talk we discuss the use of a set of reinforcement learning methods for controlling the planned rates of aircraft on a set of Traffic Management Initiatives across the Northeast United States. The work is validated through the use of a fast-time air traffic management simulation.

■ MA52

CC- Skagit 1

Choice-Modeling and Price Optimization

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Ovunc Yilmaz, University of Notre Dame, South Bend, IN, 46617, United States

Co-Chair: Alper Arslan, Queen’s University, Kingston, ON, Canada

1 - Capacitated and Bounded Pricing under Multinomial Logit Choices and Applications in the Hotel Business

Gwangjae Yu, Arizona State University, Tempe, AZ, 85281, United States, gjyu@asu.edu, Hongmin Li, Scott Webster

We consider a capacitated pricing problem in which a firm determines prices of multiple substitutable products when the supply or capacity of the products are constrained and prices are bounded. This problem applies broadly to many industries; we illustrate an application in the hotel business.

2 - Price Equilibrium under Heteroscedastic Exponomial Choice

Aydin Alptekinoglu, The Pennsylvania State University, University Park, PA, 16802, United States, aydin@psu.edu, John H. Semple

We analyze the price equilibrium among an oligopoly of single-product firms under Heteroscedastic Exponomial Choice. Of theoretical interest is the impact of heteroscedasticity on equilibrium prices, which is new to the discrete choice literature. We find that the individual and collective incentives differ in equilibrium: Firms individually want lower error variability for their own product, but collectively prefer higher error variability for all products - including their own - because higher error variability softens the price competition. Of empirical interest, the equilibrium is unique and it can be very easily computed.

3 - A Comparative Empirical Study of Discrete Choice Models in Retail Operations

Gustavo J. Vulcano, Universidad Torcuato di Tella, Av Figueroa Alcorta 7350, Suite 405, Buenos Aires, 1428, Argentina, gvulcano@utdt.edu, Gerardo Berbeglia, Agustin Garassino

Demand estimation is a fundamental task in retail operations and revenue management. In addition to the classical multinomial logit (MNL) model and its variants, new demand models have been proposed (e.g., the Markov chain model) and others have been revisited (e.g., the rank-based and exponomial models). At the same time, new computational approaches were developed to ease the estimation function (e.g., column generation, EM algorithms). In this work, we conduct a systematic, empirical study of different demand models and estimation algorithms, and characterize operational environments suitable for different implementations.

4 - Football Ticket Pricing for Multiple Sale Channels with Heterogeneous Customers

Hayri Alper Arslan, Queen's University, Kingston, ON, Canada, arslan.alper@econ.queensu.ca, Ovunc Yilmaz, Robert Easley, Ruxian Wang

Football teams face a pricing problem different than baseball, basketball, and hockey teams partly due to fewer home games per season and more season tickets sold. Dynamic pricing which focuses on single-game ticket pricing has limited value in this setting, therefore most football teams use variable pricing where they charge different prices for (i) different seat categories and (ii) different games. In this paper, we develop a data-driven framework to study a price optimization problem for multiple sales channels (i.e., season tickets and single-game tickets) with game demands given by a discrete mixed multinomial logit (MMNL) model.

■ MA53

CC- Skagit 2

Innovative Pricing Strategies

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Pnina Feldman, Boston University, Boston, MA, 02215, United States

1 - Pricing Capacity Over Time and Recourse Strategies: Facilitate Reselling, Offer Refunds, or Overbook?

Pnina Feldman, Boston University, Questrom School of Business, 595 Commonwealth Avenue, Boston, MA, 02215, United States, pninaf@bu.edu

Perishable capacity is often sold before it is used which creates the opportunity to include in the pricing mechanism a recourse strategy, such as resale, refunds and overbooking. We investigate alternative recourse strategies and the implication for firm's profit and social welfare.

2 - Fake Reviews

Chen Jin, National University of Singapore, Singapore, 117417, Singapore, Luyi Yang

We study fake reviews in a competitive online environment.

3 - Experiential Retailing and Pricing Implications

Nevin Mutlu, Eindhoven University of Technology, UCLA Anderson School of Management, Operations and Technology Management, Eindhoven, 90095-1481, Netherlands, Hadi El-Amine, Ozge Sahin

Fueled largely by the millennial generation, consumer preference for spending goes more to experiences over objects. In this paper, our goal is to study the impact of offering experiential services in brick and mortar stores on retailers' prices and profits. We identify cases where retailers and consumers benefit from augmented retail experiences.

4 - Online Learning and Decision-making under Generalized Linear Model with High-dimensional Data

Xue Wang, Pennsylvania State University, , University Park, PA, 16802, United States, wxie91@gmail.com, Mingcheng Wei, Tao Yao

In this study, we consider the online learning and decision-making problem with high-dimensional covariates. We penalize the bandit model with Minimax Concave Penalty (MCP-bandit) to handle the high-dimensional issue. Under epsilon-decay sampling scheme, we show the cumulative regret of MCP-bandit is upper bound O(s^3log d log T), where s is the sparsity level, d is the total dimension and T is the time length.

■ MA54

CC- Skagit 3

Dynamics in Online Platforms

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Yonatan Gur, Stanford University, Stanford, CA, 94305, United States

Co-Chair: Daniela Saban, Stanford University, Palo Alto, CA, 94305, United States

1 - Sequential Procurement with Contractual and Experimental Learning

Gregory Macnamara, Stanford University, Stanford, CA, United States, Yonatan Gur, Daniela Saban

We study the design of sequential procurement strategies that integrate stochastic and strategic information. We consider a buyer who repeatedly demands one unit of the same good and cannot commit to long-term contracts. In each time period, the buyer makes a price offer to a seller who has private, persistent information regarding his cost and quality. If the offer is accepted, the seller provides the good with a stochastic quality that is not contractible; otherwise, the buyer sources the good from a known outside option. The buyer can learn from observations of the strategic acceptance decisions taken by the seller, and from evaluations of the stochastic quality delivered whenever a purchase occurs.

2 - The Impact of Service Experience on Engagement: Empirical Evidence from Ride-sharing

Baek Jung Kim, New York University, New York, NY, United States, bkim2@stern.nyu.edu, Maxime Cohen

When experiencing a low-service quality, customers may stop using the service and switch to a competitor. In the context of ride-sharing, we study how different quality dimensions affect customers' usage. Using a rich dataset including detailed rides information of 5,269,413 rides, we show evidence that low-service quality has a negative impact on usage. We then build and estimate a structural demand model of riders, including dynamic effects of service quality and its inter-temporal dependence via the goodwill-stock framework to quantify the economic value of each service -quality dimension.

3 - Learning Customer Preferences from Personalized Assortments

Yifan Feng, University of Chicago, Chicago, IL, 60637, United States, yifan.feng@chicagobooth.edu, Rene A. Caldentey, Christopher Ryan

A company wishes to commercialize the best version of a product out of a menu of available alternatives. The company does not know customers' preferences over the set of alternatives and relies on a voting system that allows potential buyers to vote for their preferred version. Under a general ranking-based choice model framework, we study how to dynamically customize each individual voter's choice set, so as to identify the top-ranked alternative with a fixed probabilistic confidence level, while using a minimal number of votes.

4 - Substitutes or Complements: Consumption of News, Fake News and Fact-checks.

Senthil Veeraraghavan, University of Pennsylvania, Wharton School OPIM Department, Philadelphia, PA, 19104, United States, senthilv@wharton.upenn.edu, Jiding Zhang, Ken Moon

Fake news reduces quality of factual coverage, affects the political stability and informedness of citizenry. In this paper, using an individual-level panel data, we study the demand and consumption patterns of news from mainstream publications, fake articles and fact-checking websites. We disentangle the possible mechanisms of consuming fake news: idiosyncratic preference, event-driven utility shocks, and complementarity. We show that in general fake news complement with fact-checking, but there is a negative correlation between the idiosyncratic utility of fake news and fact checking.

■ MA55

CC- Skagit 4

Revenue Management and Market Analytics III

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Gabriel Weintraub, Stanford Graduate School of Business, Stanford, CA, 94304, United States

1 - Information Disclosure in Online Platforms: Optimizing for Supply

Yiangos Papanastasiou, University of California Berkeley, Haas School of Business, 2220 Piedmont Ave, Berkeley, CA, 94720, United States, yiangos@haas.berkeley.edu

This paper studies the interaction between information disclosure in two-sided online platforms and the composition (quantity and quality) of service providers active in the platform.

2 - Autonomous Vehicle Market Design

Garrett van Ryzin, Head of Marketplace Labs, Lyft, New York, NY, United States, Zhen Lian

We analyze a model of autonomous vehicle (AV) ride hailing markets in in which uncertain aggregate market demand can be served using a combination of a fixed fleet of AVs and human driver contractors. We compare the equilibrium profits of a ride hailing firm under the pure-AV and mixed AV-human-driver service models and examine the impact of a consolidated vs. separate dispatch market designs.

3 - Quality Selection in Two-sided Markets

Bar Light, Stanford, Stanford, Stanford, CA, United States, Ramesh Johari, Gabriel Weintraub

In two-sided markets, platforms acquire information about both buyers and sellers. Platforms use this information to increase their revenue and to enhance the welfare of the platform's participants. For example, platforms such as Amazon Marketplace, Upwork, and eBay suspend or ban low quality sellers from participating in their platforms, and provide information to buyers about the sellers that participate in their respective platforms. In this paper we examine how much information a platform should share in order to maximize its revenue.

4 - Persuasion in Networks: Public Signals and K-cores

Ozan Candogan, University of Chicago, Booth School of Business, Chicago, IL, 27708, United States, ozan.candogan@chicagobooth.edu

We consider a setting where agents in a social network take binary actions, which exhibit local strategic complementarities. Agents are a priori uninformed about a payoff-relevant state. An information designer chooses a public signaling mechanism that sends informative signals about the state to maximize the expected number of agents who take action 1. We characterize the structure of optimal public signaling mechanisms. We show that the optimal mechanism (i) publicly reveals which core of the network should take action 1 in an incentive compatible way, and (ii) admits a novel 2-interval structure.

■ MA56

CC- Skagit 5

Topics in Revenue Management

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Stefanus Jasin, University of Michigan, Ann Arbor, MI, 48105-9461, United States

Co-Chair: Sheng Liu, University of California-Berkeley, Berkeley, CA, 94709, United States

1 - Is Model Misspecification Detrimental for the Data-driven Newsvendor?

Gah-Yi Ban, London Business School, Regent's Park, London, NW1 4SA, United Kingdom, gban@london.edu, Zhenyu Gao, Fabian Taigel

We compare solving the data-driven newsvendor problem under three well-known paradigms: Bayesian, Frequentist Parametric and Nonparametric. For the Bayesian and Frequentist Parametric approaches, we consider the effects of model mis-specficiation. We make comparisons analytically, using tools from asymptotic statistics, and empirically, on simulated data and on a real-life data set from a large fresh food chain.

2 - Dynamic Inventory Allocation with Demand Learning for Seasonal Goods

He Wang, Georgia Institute of Technology, H. Milton Stewart School of Industrial & Sys, Atlanta, GA, 30332-0205, United States, Milashini Nambiar, David Simchi-Levi

We propose a dynamic learning approach to allocating seasonal goods to retail stores in one-warehouse multiple-retailer setting. At the start of the selling season, a fixed amount of inventory is available at the warehouse, with no additional replenishment. In each period, the decision maker can allocate inventory from the warehouse to the retailers. The allocation decision must be non-anticipating, in that it can only depend on demand forecasts and demand realizations seen at the retailers thus far.

3 - Multiproduct Pricing under the Generalized Extreme Value Models with Homogeneous Price Sensitivities

Heng Zhang, University of Southern California, Los Angeles, CA, 91776, United States, Paat Rusmevichientiong, Huseyin Topaloglu

We consider unconstrained and constrained multiproduct pricing problems under an arbitrary GEV model when products have the same price sensitivity parameter. We show that the optimal prices of the different products have a constant markup in the unconstrained problem. In the constrained one, we assume the expected sales of the products are constrained to lie in a convex set. We give an equivalent market-share-based formulation, where the purchase probabilities of the products are the decision variables. We show that this is a convex program, and the gradient of its objective function can be computed efficiently. We can recover the optimal prices for the products by using the optimal market shares.

4 - Dynamic Joint Assortment and Pricing Optimization with Demand Learning

Sentao Miao, University of Michigan-Ann Arbor, Ann Arbor, MI, 48104, United States, semiao@umich.edu

We consider a joint pricing and assortment selection problem where customers arrive sequentially and make purchasing decisions following a multinomial logit (MNL) choice model. Not knowing the customers' choice parameters a priori and subjecting to a display capacity constraint, we dynamically determine the subset of products for display and the selling prices to maximize the expected total revenue over a selling horizon. We design an algorithm which uses the method of random sampling, and an instance-independent upper bound for the Bayesian regret of our algorithm is obtained. Numerical results show that it performs very well.

5 - Urban Consolidation Center or Peer-to-Peer Platform? The Solution to Urban Last-Mile Delivery

Yun Fong Lim, Singapore Management University, Lee Kong Chian School of Business, 50 Stamford Road, 04-001, Singapore, 178899, Singapore, yflim@smu.edu.sg, Qiyuan Deng, Xin Fang

The growth of urban population and e-commerce activities increases the demand for urban last-mile delivery. To reduce traffic congestion, an urban consolidation center (UCC) bundles shipments from multiple carriers before delivering them to a city center. Despite the potential benefits, the adoption rate of UCCs in practice is low. In contrast, a notable number of peer-to-peer platforms have been established recently to share delivery capacity. We compare the performance of these two business models. We study a game-theoretical model involving a consolidator, who operates a UCC or a capacity sharing platform, and multiple carriers, who choose whether to use the consolidator's service.

■ MA57

CC- Yakima 1

Location and Logistics

Sponsored: Location Analysis

Sponsored Session

Chair: Sibel Alumur Alev, University of Waterloo, Waterloo, ON, N2L 3G1, Canada

1 - A New Approach for Modeling and Solving Refueling Station Location Problem with Routing

Omer Burak Kinay, University of Waterloo, Waterloo, ON, Canada, obkinay@uwaterloo.ca, Fatma Gzara, Sibel Alumur Alev

In this study, we address charging infrastructure planning for electric vehicles and propose the full coverage approach for refueling station location problem with routing. The aim is to minimize the total fixed cost of establishing charging stations as well as the total recharge to complete every origin-destination trip. We take drivers' willingness to deviate from their shortest paths into account and consider the routing aspect of the problem by finding the optimal deviation paths. In order to tackle real-life instances of the problem, a Benders decomposition algorithm is proposed.

2 - Covering Vehicle Routing Problem: Applications for Refugee Related Services

Bahar Yetis Kara, Bilkent University, Department of Industrial Engr., Ankara, 06800, Turkey, bkara@bilkent.edu.tr, Elfe Buluc

Providing "Child Friendly Spaces (CFS)" to vulnerable refugee children are addressed in this study. The mobile CFS problem is determining the stay-over points for the trucks while maximizing the number of children reached and the routes of the trucks while minimizing the total distance travelled. The studied problems are categorized as Covering Vehicle Routing Problem with and without Integrated Tours both of which are new to the location and routing literature. Mathematical models and optimization based heuristics for different versions of the problems are introduced. The proposed solutions are applied to a real life case of city Kilis.

3 - Stochastic Districting Models

Stefan Nickel, Karlsruhe Insitute of Technology, Institute for Operations Research, Karlsruhe, 76131, Germany, stefan.nickel@kit.edu, Antonio Diglio, Francisco Saldanha-da-Gama

Districting Problems (DPs) aim at partitioning a set of basic geographic areas, named Territorial Units (TUs), into a set of larger clusters, called districts, according to some planning criteria. The latter typically refer to balancing, contiguity and compactness. In this paper, we introduce a Stochastic Districting Problem with Recourse (SDPR) whose aim is to partition a given set of TUs into a prefixed number of clusters in order to maximize the overall compactness and to meet balancing constraints, expressed in terms of average demand per district. Demands associated to each TU are modeled as random variables. The problem is formulated as a two-stage stochastic program with recourse.

4 - Store Location with Multipurpose Shopping Trips and Discrete Choice

Vladimir Marianov, Pontificia Universidad Catolica de Chile, Department of Electrical Engineering, Vicuna Mackenna 4860, Santiago, 782-0436, Chile, marianov@ing.puc.cl
Vladimir Marianov, Complex Engineering Systems Institute, Santiago, Chile, marianov@ing.puc.cl, Armin Lüer-Villagra, H.A. Eiselt

Nearly all store location models assume that customers make single purpose trips. In practice, consumers purchase more than one product during a trip. Recently, the issue was included in a model for the location of commercial facilities, in which a customer purchased one or two products in a trip depending on the perceived utility. The rule for choosing what trip to engage in was deterministic. We introduce a discrete-choice model, and allow the entrant firm to find the best price for its product. We provide preliminary test results.

■ MA58

CC- Yakima 2

Law and Fairness in OR

Emerging Topic: Policy & Government

Emerging Topic Session

Chair: Swati Gupta

1 - Fairness in School Matching

Xuan Zhang, Columbia University, New York, NY, 10025, United States, Yuri Faenza, Swati Gupta

The Gale-Shapley stable matchings model is widely used in school admissions. Under this model, schools are required to rank students in their order of preference. However, the way in which students are evaluated may be subject to unintended bias due to various factors. We study the problem by mathematically modeling “perceived bias”. In particular, we assume students’ true potential follows a certain continuous distribution but some students’ evaluated potentials are scaled down by a discount factor (<1) due to biases. We investigate the impact of this bias on students as well as on the schools. We propose multiple solutions to alleviate the adverse effects of bias in school admissions.

2 - Infrastructure Impacts of Fairness in Electricity Policy

Valerie Thomas

Please check the mobile app for this abstract.

3 - Preference Elicitation for Participatory Budgeting

Gerdus Benade, Carnegie Mellon University, Pittsburgh, PA, United States, Ariel Procaccia, Swaprava Nath, Nisarg Shah

Participatory budgeting enables the allocation of public funds by collecting and aggregating individual preferences. Making the most of this new paradigm requires a rethinking of some of the basics of computational social choice, including the very way in which individuals express their preferences. We analytically compare four preference elicitation methods, knapsack votes, rankings by value or value for money, and threshold approval votes, through the lens of implicit utilitarian voting, and find that threshold approval votes are qualitatively superior. This conclusion is supported by experiments using data from real participatory budgeting elections and a user study.

4 - Learning Optimal and Fair Decision Trees for Non Discriminative Decision Making

Sina Aghaei, University of Southern California, Los Angeles, CA, United States, saghaei@usc.edu, MohammadJavad Azizi, Phebe Vayanos

Recently, automated data-driven decision-support tools are increasingly being used in socially sensitive settings. Yet, they may result in discriminative decisions in that they may treat individuals from a specific group unfairly, resulting in disparate treatment and/or impact and violating moral or ethical standards. In this paper, we unify unfairness definitions across classification and regression and propose a mixed integer optimization framework for learning optimal and fair decision trees to prevent disparity. We conduct extensive computational studies that show that our framework yields non-discriminative decisions at lower cost to overall accuracy than other approaches.

■ MA58a

CC- Chelan 1

8:00-8:45 Artleys Corp. / 8:45-9:30 GAMS

Vendor Tutorial

1 - Nonlinear Optimization Using Artelys Knitro with Julia/JuMP

Richard Waltz, Artelys, 6932 W. 85th Street, Los Angeles, CA, 90045-2603, United States

Artelys Knitro is the premier solver for nonlinear optimization problems. Julia is a free, open-source, high-level programming language for technical computing that also comes with an optimization modeling language JuMP. This software demonstration will highlight the newly released Knitro interface to Julia/JuMP. This interface leverages the new C API in Knitro to exploit problem structures such as quadratic and conic constraints. The Knitro C API can be called directory through Julia to access all Knitro features. Alternatively, Knitro may be used through the JuMP modeling language, which provides automatic differentiation for nonlinear functions. We will demonstrate both approaches as well as benchmarking features provided through this interface.

2 - Deploying Models with GAMS MIRO

Lutz Westermann, GAMS, 1217 Potomac Street NW, Washington, DC, 20007, United States, Michael Bussieck, Steven Dirkse

Are you a model developer wanting to run your GAMS application from within a web browser, with convenient visualization of input and output data? Or an enterprise requiring a graphical user interface so that planners can work more productively, leveraging the full potential optimization brings? During this tutorial, we will introduce GAMS MIRO, a web interface for your GAMS models. We will start explaining the fundamental concepts of GAMS and the advantages of using GAMS to build optimization-based decision support applications. We will continue with the various options to connect GAMS models to other application and briefly cover some recent developments. The central part of the tutorial will be about GAMS MIRO. It has tight connections to the GAMS modeling system that allow you to perform data manipulation, scenario management, graphical evaluation of the results and much more from within the web browser by adding very few annotations to your model. You specify which input and output datasets you want to visualize, and the result is a fully functional GUI that can be launched directly from the new GAMS Studio or via a shortcut on your Desktop. GAMS MIRO also facilitates the generation, organization, and sensitivity analysis of multiple scenarios of an optimization model. A server version will support additional features: managing multiple optimization models for concurrent users with access management, load balancing, batch configuration and much more.

■ MA59

CC- Chelan 2

Joint session QSR/Practice:Navigating Promotion & Tenure: A Guide for Assistant Professors

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Ahmed Aziz Ezzat, Rutgers University

Co-Chair: Mohammed Shafae, University of Arizona, Tucson, AZ, 85721, United States

Moderator

Mohammed Shafae, University of Arizona, Tucson, AZ, 85721, United States

Tenure in or and Isye Departments, Moving on the Tenure Track, Perspectives from the Tenure Committee, Parenting on the Tenure Track

Laura Albert, University of Wisconsin-Madison, Industrial & Systems Engineering, Madison, WI, 53706, United States, laura@engr.wisc.edu

Panelists

- Alaa Elwany, Associate Professor, Texas A&M University, College Station, TX, 77843, United States, elwany@tamu.edu
- Young-Jun Son, University of Arizona, Systems and Industrial Engineering, Tucson, AZ, 85721-0020, United States
- Jennifer A. Pazour, Rensselaer Polytechnic Institute, Troy, NY, 12180-3522, United States, pazouj@rpi.edu

■ MA59a

CC- Chelan 3

Data Mining I

Contributed Session

Chair: Samuel Davis, Northeastern University, Boston,MA, United States

1 - Towards Interpretable and Actionable Random Forest Classification Models

Abdelaziz Berrado, University Mohammed V. in Rabat, Rabat, Morocco, berrado@emi.ac.ma

The lack of interpretability of random Forest models is the main driver of this research. Our objective in this work is to expose avenues for demystifying the predictive structure of random forest classification models. We present the state of the art related to this pending research issue and present our suggested approach to prune and thereafter understand random Forest classification models.

2 - Exploring Accident Path from Incident Narratives Using Active Learning Based Text Classification

Kritika Singh, Indian Institute of Technology, Kharagpur, India, kritika.swati@gmail.com, Harshawardhan Mahajan, Rohan Singhade, J. Maiti

Literature lack effort in exploration of complete accident path from incident narratives which can be achieved with text classification (TC) model. However, it will require huge annotated data. This can be dealt by using Active Learning (AL). AL is a semi-supervised iterative technique where only most informative records are queried to human annotator for labels and remaining unlabeled records are labeled using TC algorithm In this work we have developed an AL model using SVM, which was applied on 612 process incident reports and 190 accident paths were obtained. The proposed method outperformed other TC algorithms (SVM, Naïve Bayes and k-Nearest Neighbor).

3 - Matched Forest: Supervised Learning for High-dimensional Matched Case-control Studies

Nooshin Shomalzadeh, Arizona State University, Tempe, AZ, United States

Matched case-control analysis is widely used in biomedical studies to identify exposure variables associated with health conditions. Matching is used to improve the efficiency by enforcing cases and controls to have the same distribution of confounding variables. Existing variable selection and classification methods for matched case-control studies are challenged in high-dimensional settings where interactions among variables are also important. We describe a quite different method for analyzing high-dimensional matched case-control data set which is not only flexible regarding the number of matching and exposure variables and but also able to detect interaction effects.

4 - Systematic Examination of Pruned and Aggregated Leaves Improves Decision Tree Accuracy

Samuel R. Davis, Northeastern University, Boston, MA, United States, davis.sam@husky.neu.edu, Sara Nourazari, Nasser S. Fard

Decision trees (DTs) often suffer from two issues: small leaves are prone to over-fitting training data, and impure leaves have significant prediction error. Pruning balances these objectives by merging shared-parent leaves, whereas separate-and-conquer approaches cover the feature space using rules. Systematic examination of pruned and aggregated leaves (SEPAL) eliminates the shared-parentage constraint, thus simultaneously pruning and aggregating leaves that are statistically similar by iteratively reducing and re-modeling the training data. Results demonstrate consistent improvement upon the classification and regression tree (CART) methodology of inducing decision trees.

■ MA60

CC- Chelan 4

QSR Best Student Paper Competition

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Eunshin Byon, University of Michigan, College Station, MI, 48109-2117, United States

Co-Chair: Wenmeng Tian, Mississippi State University, Mississippi State, MS, 39762, United States

Co-Chair: Mingyang Li, Tampa, FL, 33647, United States

1 - Optimal Sequential Subspace Change-point Detection

Liyan Xie, Georgia Institute of Technology, Atlanta, GA, United States, Yao Xie, George V. Moustakides, George V. Moustakides

We present a novel Subspace-CUSUM procedure for a fundamental problem, to detect changes with an unknown low-dimensional subspace structure, which is manifested as a spiked covariance matrix. We show our computationally efficient Subspace-CUSUM procedure is first-order asymptotically optimal and demonstrate its competitive performance using numerical and real-data examples.

2 - An Active Learning Methodology for Efficient Estimation of Noisy Black-Box Functions using Gaussian Process Regression

Rajitha Meka, University of Texas-San Antonio, San Antonio, TX, 78230, United States, Adel Alaeddini

In many real-world problems, we encounter situations to approximate black-box functions which are expensive to evaluate. To efficiently estimate these functions using Gaussian processes, we propose an active learning methodology based on integration of Laplacian regularization, and maximum mean squared error method.

3 - Heterogeneous Information Learning in Large-Scale Networks

Xiao Huang, Texas A&M University, College Station, TX, United States, Jundong Li

Network analysis has been widely adopted in many industrial applications such as targeted marketing. Real-world nodes are often abundantly accompanied with other types of meaningful information such as node attributes. We propose a general framework to incorporate this heterogeneous information into network embedding to learn better node vector representations.

4 - Image-Based Process Control Using Tensor Analysis

Zhen Zhong, Georgia Institute of Technology, Atlanta, GA, United States, Kamran Paynabar, Jianjun Shi

High-dimensional process control strategies should be deployed to ensure on-target quality in many applications. To address this, we propose a novel tensor-based process control approach by incorporating the tensor time series and regression techniques. Simulation and case studies show that our proposed method is more effective than the benchmark.

■ MA61

CC- Chelan 5

Data Science for Quality and Reliability Assurance

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Jianguo Wu, Peking University, Beijing, 100080, China

Co-Chair: Mingyang Li, Tampa, FL, 33647, United States

1 - Gaussian Process Model with Non-vectorial Inputs and its Application to Design of Printed Antennas

Xi Chen, University of Arizona, Tucson, AZ, 85721, United States, xic@email.arizona.edu, Qiang Zhou

The conventional Gaussian Process (GP) model setting deals only with a scalar output and input in a vector form, i.e. a list of parameters. However, many modern engineering simulations take inputs of 2D/3D part designs where the spatial information matters, thus cannot be well described by a simple vector. We proposed in this paper a general GP-based surrogate modeling framework with spatially structured input and applied it to the design of printed antennas.

2 - Multi-objective Optimal Design for Multi-state Reliability Demonstration Tests

Suiyao Chen, University of South Florida, Tampa, FL, 33617, United States, suiyaochen@mail.usf.edu, Lu Lu, Mingyang Li

Reliability demonstration tests (RDTs) are important reliability assurance activities to safeguard product reliability. Conventional designs of RDTs often consider a single objective (e.g., consumer's risk) and/or a single failure state. This work proposes an optimal design framework for multi-state RDTs by simultaneously investigating multiple and potential conflicting objectives, such as consumer's risk, producer's risk and warranty service cost. A Pareto Front approach is also employed to select the optimal test plans. A comprehensive case study is further provided to illustrate the proposed work and demonstrate its effectiveness with design insights obtained.

3 - Optimal Maintenance Management for Co-located Deteriorating Water and Transportation Systems with Interdependencies

Hung Nguyen, University of South Florida, Tampa, FL, 33613, United States, nqh@mail.usf.edu, Noha Abdel-Mottaleb, Shihab Uddin, Qing Lu, Qiong Zhang, Mingyang Li

Maintenance and rehabilitation of transportation infrastructure (TI) and water infrastructure (WI) systems are critical to nation's security and prosperity. Existing maintenance approaches often considered TI and WI separately. Due to their co-location and spatial proximity, TI and WI are physically and/or operationally interdependent. This work proposes an optimal maintenance management framework for joint maintenance prioritization and planning of interdependent TI and WI systems with a large number of co-located roads and pipes. A case study is further provided to demonstrate the cost-effectiveness of the proposed work over conventional maintenance approaches.

4 - A Functional Neural Network for Data Fusion and RUL Prediction

Yuxin Wen, University of Texas at El Paso, El Paso, TX, 79902, United States, Jianguo Wu, Bill Tseng

Accurate Remaining useful life prediction plays a critical role for effective implementation of condition-based maintenance. In this work, an effective two-stage prognostic framework is proposed to predict the remaining useful life (RUL) for individual units. Under the framework, a functional neural network that integrates multi-sensor degradation signals and time-to-event data is developed for data fusion and RUL prediction. The effectiveness of the proposed method is demonstrated through case studies.

5 - A Neural Data Fusion Model for Condition Monitoring and Residual Life Prediction

Zhen Li, Peking University, Beijing, 100871, China, zhen.li@pku.edu.cn, Jianguo Wu

Multi-sensor signals are now readily available for condition monitoring and residual life prediction. Composite health indices can be constructed by fusing these signals to better capture the health condition. However, most of the existing methods fuse signals linearly, which may not be sufficient to characterize the health condition. To address such issue, this paper develops a novel neural data fusion model for health index construction. Three loss functions are formulated by considering the monotonicity of the health index and variability at the failure point. The superiority of the proposed method is demonstrated through numerical and case studies.

■ MA62

CC- Tahoma 1

Panel: Machine Learning for Healthcare

Sponsored: Health Applications

Sponsored Session

Chair: Mohsen Bayati, Stanford University, Stanford, CA, 94305, United States

Moderator

Mohsen Bayati, Stanford University, 655 Knight Way, E363, Stanford, CA, 94305, United States

Panelists

- Carri Chan, Columbia Business School, New York, NY, 10027, United States
- Diana Maria Negoescu, University of Minnesota, Minneapolis, MN, 55455, United States
- Eric Horvitz, Microsoft Research, Redmond, WA, 98052-6399, United States
- Timothy Chan, University of Toronto, Mechanical and Industrial Engineering, Toronto, ON, M5S 3G8, Canada

■ MA63

CC- Tahoma 2

Joint Session HAS/Practice Curated: Data Analytics in Healthcare Operations

Sponsored: Health Applications

Sponsored Session

Chair: Retsef Levi, MIT, Cambridge, MA, 02142, United States

1 - Machine Learning to Address Hospital Capacity: Predicting Discharges and Identifying Barriers to Discharge

Taghi Khaniyev, MIT Sloan School of Management, Cambridge, MA, 02142, United States, khaniyev@mit.edu, Kyan Safavi, Ana Cecilia Zenteno, Jonathan Zanger, Mark Seelen, Martin S. Copenhaver, Bethany Daily, Peter Dunn, Retsef Levi

Hospital congestion is caused among other factors by an imbalance of the timing of patient admissions and discharges. We trained a neural network model to predict next-day's surgical patient discharges based on previous patients' recovery care paths at a large academic medical center. Further, we analyzed mismatches between predicted and actual discharges to identify areas for improvement in the discharge process and to enhance the accuracy of the tool. The model had an AUC of 0.89. Mismatches occurred without clinical reason 45% of the time and were due to clinical practice variation 25% of the time.

2 - Optimization of Public Access Defibrillators Compared to Guidelines-based Deployment

Christopher Sun, Massachusetts Institute of Technology, Cambridge, MA, M5G 2R2, United States, clfsun@mit.edu, Timothy Chan

Public defibrillators can be used by bystanders with no prior training to resuscitate cardiac arrest victims. Optimization has been shown to improve defibrillator location decisions by maximizing cardiac arrest coverage, a measure of spatial proximity and temporal accessibility of defibrillators to cardiac arrests, but has not been compared to established guidelines. We present a comparison of optimal defibrillator placements against guideline-based placements over a nine year study period using real patient data. Optimized locations increased cardiac arrest coverage by 50.7%-117.2% over guideline-based locations and significantly improved estimated patient outcomes.

3 - A New Patient Trajectory Simulation Method for Staffing in Care Coordination Programs

Hari Balasubramanian, Univ of Massachusetts-Amherst, Amherst, MA, 01003, United States, hbalasubraman@ecs.umass.edu, Ekin Koker, Aaron Truchil

Care Coordination programs intended to improve outcomes and lower cost of care for patients with complex health and social needs have proliferated in recent years. Staff encounters with patients in these programs can be modeled as a trajectory, each encounter marked with a staff type, duration and a timestamp from enrollment date. Using encounter data from a care coordination program, we simulate different realizations by sampling patient trajectories randomly without replacement, allowing for a constant and a Poisson patient arrival rate. We present our findings and offer insights for healthcare organizations looking to start care coordination programs.

4 - Measuring Physician Work Using Electronic Health Records

Michael Hu, MIT, Cambridge, MA, 02130, United States, hum@mit.edu, Stephanie Eisenstat, Retsef Levi, Walter O'Donnell

As electronic health records (EHRs) have become more prevalent, physicians are spending substantial time completing EHR-related work. Observational studies indicate that half of physicians' office time is spent on EHR work. Furthermore, many physicians report they are forced to complete EHR work after hours, which has significantly contributed to physician burnout. In this work we achieve the following: (1) establish a rigorous methodology for accurately measuring physician time spent on EHR tasks using click-level EHR data; and (2) explore how EHR work is distributed temporally and across different types of patients.

5 - Mixing it Up: Operational Impact of Hospitalist Workload

Masoud Kamalahmadi, Indiana University, Bloomington, IN, 47405, United States, maskamal@iu.edu, Alex Mills, Jonathan Helm, Kurt M. Bretthauer

Hospitalists are physicians that specialize in caring for hospital inpatients, replacing a primary care physician who may only make rounds once per day and thereby reducing delays. Given a limited number of hospitalists in a hospital, we seek to determine their optimal service mix (workload and patient types).

■ MA64

CC- Tahoma 3

Data & Simulation Modeling in Opioid Research

Sponsored: Health Applications

Sponsored Session

Chair: Mohammad Jalali

1 - Physician Patient-sharing Network of Chronic Opioid Users

Toyya A. Pujol, Georgia Institute of Technology, Atlanta, GA, United States, pujol@gatech.edu, Nicoleta Serban

Opioid dependence has become a US public health concern due to the increasing rates over the last 10 years; resulting in a four-fold increase in opioid related deaths from 2013 to 2016. To better understand chronic users, i.e. those most at risk for addiction, we need to know about their healthcare system and the social influence of their providers among each other. In this study, we will utilize Medicaid claims data to identify 2013 and 2014 Medicaid-insured chronic opioid users and their healthcare providers. We will create a social network in which edges represent if two physicians share a patient. The results will include analysis on the topology of the network and the initial findings.

2 - Cost-effectiveness of Treatments for Opioid Use Disorder in Veterans Affairs Patients

Michael Fairley, Stanford University, Stanford, CA, 94304, United States, mfairley@stanford.edu, Margaret L. Brandeau, Doug Owens

In the Veterans Affairs Health System (VA), which is the largest provider of healthcare in the US, the rate of fatal drug overdose among patients is twice that of the general US population and the prevalence of opioid use disorder is 7 times higher than for patients in commercial health plans. We develop a microsimulation model to evaluate the cost-effectiveness of treatments and portfolios of treatments for opioid use disorder in VA patients. We consider the following treatments: medication-assisted therapy with methadone and buprenorphine, opioid antagonist therapy with naltrexone, overdose education and distribution of naloxone, cognitive behavioral therapy and contingency management.

3 - Social Signal in the Opioid Crisis: Text Mining the Physician Review Sites

Stanislav Mamonov, Associate Professor, Montclair State University, Montclair, NJ, United States, stanislav.mamonov@montclair.edu

Overprescription of opioid pain relievers is a known contributor to the growing opioid epidemic. Identification of medical practices that engage in overprescription has proven challenging. We examine the utility of physician review websites (PRWs) as potential sources of data that may help identify overprescribing physicians. We leverage text mining techniques to identify linguistic cues that are associated with known cases of overprescription. We find that patients flag potentially problematic medical practices in their reviews and suggest that an intervention by authorities is warranted.

4 - The Unintended Consequences of Health Policy: An Empirical Analysis of Opioid Prescribing Behavior

Justin Kistler, University of South Carolina, Columbia, SC, 29212, United States, justin.kistler@grad.moore.sc.edu, Luv Sharma

As a critical component of the Patient Protection and Affordable Care Act, the Value Based Purchasing program was designed to incentivize healthcare organizations and providers to improve the safety and quality of patient care. While considerable improvement has been made in several performance domains, our empirical analysis of opioid prescription rates over a seven-year period indicates an unintended increase in opioid prescribing immediately following the implementation of the Value Based Purchasing program. Our findings also indicate the moderating impact of prescriber workload on opioid prescription rates.

5 - A Predictive Analytics Model for Opioid Treatment Completion

Hyojung Kang, University of Illinois at Urbana-Champaign, Champaign, IL, United States, hyokang@illinois.edu, Seokgi Lee

The opioid epidemic is a public health emergency in the U.S. While the number of patients attending opioid treatment has increased over the years, the rate of treatment completion has been low. To better understand characteristics of patients who complete or do not complete opioid treatments, we analyze national data sets including treatment episodes and implement a predictive analytics model based on the logical analysis data (LAD) approach.

■ MA65

CC- Tahoma 4

Joint Session HAS/Practice Curated: Queueing Models in Hospital Operations

Sponsored: Health Applications

Sponsored Session

Chair: Yichuan Ding, University of British Columbia, Vancouver, BC, V6T 1C3, Canada

Co-Chair: Opher Baron, University of Toronto, Toronto, ON, M5S 1L7, Canada

1 - Improving Patient Flow in Emergency Departments: A Question of Life or Death

Marko Duic, Southlake Regional Health Centre, Newmarket, ON, Canada

The flow of customers in any enterprise is an important challenge to get right, but in Emergency Departments bad flow actually kills patients. Getting flow right is a challenge because of conflicting incentives throughout the health system. Many providers make extensive use of “dams” and “reservoirs” to obstruct flow. An entire mythology exists in healthcare to confuse inefficiency with safety, and flow with risk. The way forward is to transform culture and incentives – a tall order in any system, let alone a safety-conscious, conservative one like healthcare. The talk will draw on examples from 20+ years of successfully leading change in Emergency Departments in Canada and the UK.

2 - The Impact of Consults on LOS in Emergency Department: North York General Hospital

Dmitry Krass, University of Toronto, Rotman School of Management, 105 St George Street, Toronto, ON, M5S 3E6, Canada, Opher Baron, Tianshu Lu, Zhoupeng Jack Zhang, Marco Duic

We empirically investigate the impact of an Emergency Department redesign project on the patients’ waiting time until initial assessment and their length of stay (LOS). We construct a system of time series models to reflect the interactions among different waiting phases throughout a patient’s LOS, as well as the interplay between the hospital’s overall service performance and the number of patients. We use a modified Multistage least square method to estimate our model. We conduct an iterative counterfactual study to evaluate the ‘net’ impacts of the project on key variables and the significance of these impacts.

3 - When System Characteristics Override Clinical Priority: An Empirical Investigation of MRI Scheduling and Service Delivery

Hossein Abouee Mehrizi, University of Waterloo, Waterloo, ON, Canada, haboueemehrizi@uwaterloo.ca, Somayeh Sadat

We conduct an empirical analysis of MRI scheduling and service delivery based on over a million records from Ontario, Canada. We show that certain system characteristics override clinical priority in patient’s access time to care, namely whether the patient’s procedure is batched with similar procedures, whether the procedure is expected to be short in duration, and overall system congestion. We also demonstrate that the duration of the MRI scan is impacted by system characteristics such as the shift the procedure takes place in, the case mix of proceeding patients, and overall clinic congestion. Our research has implications for health policy makers monitoring access to care and quality of care.

4 - Local Adjustment of Physician Schedule in Emergency Department

Yiwen Jin, University of British Columbia, Vancouver, BC, V6T1Z4, Canada, Yichuan Ding

In this paper we optimize Emergency Department (ED) physicians’ staffing by locally adjusting the shift schedule in order to minimize patients’ total waiting cost. With a local adjustment, we move the shift with high granularity instead of globally setting the staffing requirement. We consider two types of cost, the queueing backlog and patients’ total waiting cost with a piecewise linear marginal cost function. We provide two indices where we find that the essence of this problem lies in comparing busy periods. We characterize our adjustment policy through pathwise analysis of the historical data and offer instructions of implementation in a local ED.

■ MA66

CC- Tahoma 5

Personalized Medicine I

Emerging Topic: Personalized Health

Emerging Topic Session

Chair: Brian T Denton, University of Michigan, Ann Arbor, MI, 48109-2117, United States

Co-Chair: Weiyu Li, IOE Department, University of Michigan, IOE Department, Ann Arbor, MI, 48105, United States

1 - Optimal Intervention for Women with Hypertensive Disorders of Pregnancy

Esma S. Gel, Associate Professor, Arizona State University, School of Computing, Informatics and, Decision Systems Engineering, Tempe, AZ, 85287-8809, United States, esma.gel@asu.edu, Aysegul Demirtas

Hypertensive disorders of pregnancy (HDP) affect up to 10% of pregnancies around the globe. We consider the decision problem of timing of delivery for women with HDP. We formulate a discrete-time Markov decision process (MDP) model and a robust MDP model that minimize the risks of maternal and neonatal adverse outcomes, and assess their results within a probabilistic sensitivity analysis (PSA). In PSA, we evaluate the performance of candidate delivery policies based on problem instances constructed with the orders between model parameters to incorporate physicians’ intuition.

2 - Personalized Treatment for Chronic Depression with Individual Treatment Effect Estimation

Mutita Siriruchatanon, University of Washington, Seattle, WA, 98105, United States, siriruc@uw.edu, Shan Liu

In a data-rich environment, information on population and individual patient history can be used in predicting their health outcomes, which leads to early detection of ineffective treatment. To develop a computerized decision support tool for mental health care providers, we formulate an optimal treatment selection problem for chronic depression and estimate the individual treatment effects on disease transitions leveraging the subgroup progression patterns and its treatment effect distribution using simulated data. The new optimal treatment policies are obtained from an exploration of several methods on individual treatment effect estimation.

3 - A Data-driven POMDP for Optimizing Individualized Surveillance Strategies for Prostate Cancer

Weiyu Li, University of Michigan, Ann Arbor, MI, 48105, United States, weiyuli@umich.edu, Brian T. Denton

Active surveillance (AS) is a strategy that involves regular clinical examinations, biomarker tests, and biopsies to monitor patients diagnosed with low-risk prostate cancer. The ideal strategy must strike a balance between the burden of testing and the benefit of early detection of progression to high-risk prostate cancer. We propose a hidden Markov model (HMM) to estimate the progression rate of cancer, and the sensitivity and specificity of the biomarker tests using longitudinal data from a large surveillance study. We use the HMM as the basis for a partially observable Markov decision process (POMDP) and present results for optimal strategies.

4 - Effective Preventive Care Management of Multiple Chronic Conditions

Ali Hajjar, University of Wisconsin-Madison, Madison, WI, 53706, United States, hjaar@wisc.edu, Oguzhan Alagoz, Vincent Cryns

Clinical practice guidelines are poor at addressing the needs of patients with multiple chronic conditions (MCC). We develop a stochastic optimization modeling framework to personalize the management of MCC. We provide an exact solution algorithm to optimally solve the modeling framework. We demonstrate how our modeling framework can be used to personalize breast cancer screening for women with diabetes. We find some important policy insights, that were not recognized by the medical community before.

■ MA67

S- Virginia

Advances in Input Uncertainty Quantification

Sponsored: Simulation

Sponsored Session

Chair: Eunhye Song, Penn State University, University Park, PA, 16802, United States

1 - Efficient Input Uncertainty Quantification via Green Simulation Using Sample Path Likelihood Ratios

Ben Feng, University of Waterloo, Waterloo, ON, N2J 4Y3, Canada, ben.feng@uwaterloo.ca, Eunhye Song

Input uncertainty is caused by the finite-sample estimation error in the input models, which inflates the uncertainty in simulation outputs. Typical bootstrap-based procedures have a nested simulation structure that requires BR simulation runs: the outer loop bootstraps B input distributions, each of which requires R inner simulation runs. In this work, we propose an efficient green simulation input uncertainty quantification procedure that reuses the same R inner sample paths in all outer loops using appropriately defined likelihood ratios. The procedure produces asymptotically valid confidence intervals and significant efficiency gains are demonstrated in our numerical experiments.

2 - Computationally Efficient Quantification of Simulation Input Uncertainty

Huajie Qian, Columbia University, New York, NY, 10027, United States, hq2157@columbia.edu, Henry Lam

Quantifying the input uncertainty of stochastic simulation, based on variance estimation or confidence interval construction, often entails substantial simulation costs due to the nested sampling requirements of the quantification schemes. We present several related approaches to reduce these costs, utilizing optimization, subsampling, and random perturbation respectively. We explain the statistical mechanisms of these approaches and why they need significantly less simulation efforts than some previous methods. We also compare them in terms of the ease of implementation and empirical performances.

3 - Online Quantification of Input Uncertainty for Parametric Models

Tianyi Liu, Georgia Institute of Technology, Atlanta, GA, United States, tianyiliu@gatech.edu, Enlu Zhou

Quantification of Input Uncertainty has been well studied for the batch data setting where data is given and fixed. However, there lack methods to process online data. We propose an online quantification algorithm for parametric models based on a two-layer importance sampling technique, which enables assimilating online data in real-time by reusing old simulation results. Our method is proved to achieve a uniform-in-time convergence. We further show that under the same simulation budget, our new algorithm works strictly better than the direct extension of the offline Bayesian quantification method.

4 - Input Uncertainty Quantification with Empirical Dependence Information

Taeho Kim, Korea Advanced Institute of Science & Technology, Dept of Industrial & Systems Engineering, 291 Daehak-Ro, Daejeon, 305-701, Korea, Republic of, thk5594@kaist.ac.kr, Kyoung-Kuk Kim

In this work, a data-driven input modeling in multiple dimensions is proposed. By utilizing empirical copula for the dependence structure, the separate estimation of marginal and joint distributions is feasible. Then we quantify the input uncertainty by resampling methods. Under certain regularity conditions, we prove the asymptotic normality of the target estimator and the consistency of resampling-based input uncertainty quantification. This approach also allows us to decompose the input variance into the sum of the variances induced by marginal and dependence information.

■ MA68

S- University

Crowdsourcing Platforms

Emerging Topic: Sharing Economy & Crowdsourcing

Emerging Topic Session

Chair: Michael R Wagner, University of Washington, Seattle, WA, 98195, United States

Co-Chair: Soraya Fatehi, University of Washington, Seattle, WA, 98195-3200, United States

1 - The Impact of the Gig-economy on Financial Hardship Among Low-income Families

Kaitlin Daniels, Olin Business School, Washington University in St. Louis, St. Louis, MO, United States, Michal Grinstein-Weiss

We empirically measure the impact of Uber's entrance into a market on the financial health of workers. We find that low-income workers are more likely to fail to meet regular, short-term financial obligations (e.g. monthly bills) following Uber entry. We explore mechanisms and illustrate the robustness of our findings. Analysis elucidates the role of gigs like Uber within the broader economy.

2 - Courteous or Crude? understanding and Shaping User Behavior in Ride-hailing

Yunke Mai, University of Kentucky, Lexington, KY, United States, yunke.mai@duke.edu, Bin Hu, Sasa Pekec, Yuhao Hu, Zikong Zou

We build an evolutionary game theory model to investigate how riders' and drivers' behavior evolves in response to a ride-hailing platform's operational decisions. We identify two sustainable asymptotically stable equilibria of the dynamic system of the platform, one resembling a traditional taxi service while the other resembling a successful ride-hailing platform. Using this characterization, we then show how the platform could leverage operational tools at its disposal to optimize its performance. Finally, we establish that a platform can generally improve social welfare and may achieve the socially optimal state by prioritizing high-rating riders in matching under supply shortage.

3 - Analysis of Public Attitude Towards Bikeshare Using Crowdsourcing Data

Xiaodong Qian, University of California-Davis, Davis, CA, United States, xdqian@ucdavis.edu

Bikesharing system is a convenient and environmental-friendly way to finish short-distance trips. However, there always exists access barriers for people to enjoy this convenient transportation model. Bikeshare system planners want to cover more and more potential users with a certain amount of bikeshare stations because of limited budgets. Currently, there are multiple online crowdsourcing data showing people's attitude towards bikeshare and providing suggestions for potential bikeshare stations. This research is aimed at analyzing these crowdsourcing data using natural language processing technology and developing a location optimization model based on crowdsourcing data.

4 - Crowdsourcing Last-mile Deliveries

Soraya Fatehi, University of Washington, Michael G. Foster School of Business, University of Washington, Seattle, WA, 98195-3200, United States, sfatehi@uw.edu, Michael R. Wagner

We study labor planning and pricing for crowdsourced last-mile delivery systems that are utilized to deliver on-demand orders. We develop our model by combining crowdsourcing, robust queuing, and robust routing theory, which allows for capturing uncertainties, trend and seasonality in: customer demands, crowd availability, service times, and traffic patterns. For a given delivery time window and a guarantee level to deliver on-time, we analytically derive the optimal delivery assignments to available independent crowd drivers and compute their optimal hourly wages. Amazon, Postmates, and UberEATS are among the companies that are utilizing crowdsourcing for last-mile deliveries.

■ MA69

S- Seneca

SpORts Analytics I

Sponsored: SpORts

Sponsored Session

Chair: Keith A Willoughby, University of Saskatchewan, Saskatoon, SK, S7N 5A7, Canada

1 - Evaluating Player Dominance and Game Outcome: The Case of Curling

Keith A. Willoughby, University of Saskatchewan, Department of Finance and Mangement Science, Saskatoon, SK, S7N 5A7, Canada, willoughby@edwards.usask.ca, Kent Kostuk

Curling is a winter team sport popular in Canada, Europe, the northern United States and the Pacific Rim. Typically, curling teams are comprised of four players (lead, second, third and skip). Team members slide 45-pound circular disks of polished granite down a sheet of ice. A scorer evaluates the success of each shot on a 4-point scale. Using data from Canadian national championships, we compare the percentage score differences between each team's corresponding players and evaluate its impact on the game outcome.

2 - Patterns of Game Play in Irish (Gaelic) Football – A Social Network Analysis Approach

Vincent Hargaden, Associate Professor, University College Dublin, School of Mechanical & Materials Engineering, Engineering & Materials Science Centre, Belfield, D04 V1W8, Ireland, vincent.hargaden@ucd.ie

Irish (Gaelic) football is a 15-a-side field sport played through a combination of hand and foot passing. Each year from May through September, the elite teams compete in a series of conference and play-off games to determine the championship winner. Similar to many team sports (e.g. basketball, soccer etc.) it is of interest to analyse the players' interaction and cooperation from a network perspective. Using hand and foot passing data between players from games involving the four-in-a-row title winning team (2015-2018), we take a social network analysis approach to identify players' interactions and the team style of play.

3 - Dynamically Scheduling NFL Games to Reduce Strength of Schedule Variability

Ben Grannan, Furman University, Greenville, SC, 29617-7908, United States, Elizabeth Bouzarth, Andrew Cromer, Jamie Fravel, Kevin Hutson

The National Football League (NFL) schedules regular season games so that some matchups are based on the previous year's results. Since team composition changes from year to year, this scheduling policy creates variation in teams' strength of schedules and sometimes benefits teams unfairly, allowing some an easier path to the playoffs than others. We propose methods to produce an NFL schedule that combine some of its traditional elements with dynamically scheduled games aimed at optimizing different objectives, such as reducing the variability of teams' strengths of schedule or minimizing the number of pairwise comparisons needed to differentiate team quality.

4 - A Comparison of Official Sports Rating Systems at Predicting World Team Championship Matches

Raymond T. Stefani, Professor Emeritus, California State University, Long Beach, CA, 92630-2633, United States, Raymond.stefani@csulb.edu

The study includes all team sports with recognized federations that publish an official rating system and conduct a world championship. The 15 sport-rating system combinations were evaluated using 56 world championships and 2941 matches. Rating systems adjusted by the difference between an opponent-dependent prediction and the actual match result were 82% accurate at predicting match winners in netball, Rugby union, women's soccer, ODI cricket, T20 cricket and men's soccer. Rating systems that accumulated result points, generally not opponent-dependent, were only 74% accurate in water polo, Rugby 7s, field hockey, ice hockey, basketball, volleyball, handball, Rugby league and curling.

5 - Estimating the Impact of Mega-sporting Events on International Tourism, the Olympic Legacy

Steven E. Moss, Professor of Business Analytics, Georgia Southern University, Statesboro, GA, 30458, United States, smoss@georgiasouthern.edu, Jun Liu, Janet Moss

Tourism legacies are often used as a key justification for hosting the Olympics. Theoretical arguments have been made to support a positive tourism legacy. A time series methodology that controls for problems noted in prior studies, such as pre-existing trends, external events, seasonality, and the crowding out effect, is needed to isolate the legacy effect. Prior research has included simple pre-post aggregate differences, relative comparisons to similar cities, trend-line extension models and structural break tests. This research uses data from ten prior Olympics. Two methodologies are used in this research, structural change tests in regression models and outlier testing in SARIMA models.

6 - Selection & Shrinkage Method Comparison for Explaining NCAA FBS Athletic Contributions

Liz A. Wanless, Ohio University, Athens, OH, United States, wanless@ohio.edu

NCAA FBS athletic programs depend on contributions as a vital financial resource. A large mix of potential explanatory variables, limited population size, and wide-ranging revenues complicate the modeling process. The purpose of this project is to evaluate model selection and shrinkage method performance for explaining FBS athletic contributions. For one athletic fiscal year, 2016-2017, NCAA FBS market, university, athletic department, and athletic development department variables were collected along with athletic contributions as the response. Method performance with specific regard to statistical versus practical relevance will be discussed.

■ MA70

S- Jefferson A

Digital Platforms

Sponsored: EBusiness

Sponsored Session

Chair: Tingting Nian, University of California, New York, NY, 10012, United States

1 - The Impact of Airbnb's Entry on Financial Delinquency

Jinan Lin, University of California, Irvine, Irvine, CA, United States, Tingting Nian, Vijay Gurbaxani

Policy debates continue on whether and how digital economy impacts local economic activities and organizations. As one of the most prominent peer-to-peer digital platforms for home sharing, Airbnb has raised much attention from local regulators. This paper investigates the impact of an entry of the home-sharing platform on zip-code level households' financial decisions. Our results suggest that the entry of Airbnb mostly affects households' short-term borrowing decisions.

2 - The Impact of Subscription Reciprocity on Charitable Content Generation and Sharing: Evidence from Twitter

Xue Tan, Indiana University, Kelley School of Business, Bloomington, IN, 47405, United States, Yingda Lu, Yong Tan

This paper investigates the impact of reciprocal and non-reciprocal followees (people who are being subscribed to) on followers' decisions to generate and share content. Leveraging a charitable movement on Twitter, we find that only reciprocal followees' participation prompts users to generate original content about this movement; participation of both reciprocal and nonreciprocal followees promotes content sharing, with nonreciprocal followees having a larger impact. Our study draws on social capital theory, and has great implications on diffusion theories concerning the strength of ties and contagion complexity.

3 - Adopting Seeker and Peer Feedback in Ideation Contests: An Anchoring Effect Perspective

Tat Koon Koh, Hong Kong University of Science and Technology, Kowloon, Hong Kong

Solution-seeking firms (seekers) can use online ideation contests to engage agents (solvers) in the crowd to generate ideas for addressing specific problems. An integral aspect of these contests is the solvers' use of feedback during ideation. In this study, we examine solvers' use of developmental feedback in their ideas by considering the anchoring heuristic that affects their decision-making. During contests, solvers can receive feedback from different sources (i.e., seekers or peers) and of different levels of practicality (i.e., the extent that the feedback is helpful and appropriate). In our theorizing, we formulate distinct expectations about how solvers anchor their ideas to seeker feedback and peer feedback, which we use to hypothesize the impact of feedback source and practicality on solvers' feedback use. In our first experiment, we show that solvers use feedback from seeker and peer differently. Specifically, solvers use low-practicality seeker feedback 1) about as much as they use high-practicality seeker feedback and 2) much more than they use low-practicality and high-practicality peer feedback. Such solver behaviors indicate a potential drawback of encouraging seeker feedback, which is prevalent on contest platforms. In our second experiment, we test a mechanism to address the downsides arising from the anchoring on feedback, particularly the overuse of low-practicality seeker feedback and underuse of high-practicality peer feedback. Our findings provide (i) insights into the scope of the anchoring effect and solvers' use of feedback and (ii) suggestions to better engage the crowd in ideation contests.

4 - The Influence of Self-Regulation of Sharing Economy: Evidence from Unstructured Information Disclosure

Zixuan Meng, University of Washington, Seattle, WA, 98105, United States, Zhijie Lin, Yingfei Wang, Yong Tan

This study analyzes the effectiveness of self-regulation disclosure in the sharing economy. Using the data from a large peer-to-peer meal-sharing platform in China, we integrate econometric analysis method with deep learning and computer vision techniques to conduct the analysis. We find that while the disclosure in general brings a sales increase to the inspected suppliers, disclosing image information only can create mis-interpretation, leading a non-monotonic sales increase in hygiene quality. We also find that competition and reputation are substitute to the self-regulation mechanism.

■ MA71

S- Jefferson B

Joint Session BOM/Practice Curated: Behavioral Operations for Social and Environmental Responsibility

Sponsored: Behavioral Operations Management

Sponsored Session

Chair: Leon Valdes, University of Pittsburgh, Pittsburgh, PA, 15260, United States

1 - How Supply Chain Risks Influence Supplier Selection and Ordering Decisions: A Behavioral Investigation

Vincent Yu, Carlson School of Management, University of Minnesota, Minneapolis, MN, United States, yuxxx952@umn.edu, Karen L. Donohue

In this study, we combine modeling and experimental methods to investigate how sourcing managers make order allocation decisions between a high-cost supplier and a low-cost supplier with some potential risks. We consider two types of risk: (1) supply risk, which arises from reliability-related issues that disrupt the flow of supply, and (2) demand risk, which results from responsibility-related issues that influence the flow of customer demand. We examine how sourcing decisions are made in light of these risks, what implications this behavior has for firm profit, and whether this behavior encourages or detracts suppliers from investing in risk reduction efforts.

2 - How Transparency into Internal and External Responsibility Initiatives Influences Consumer Choice: Evidence from the Field and Lab

Ryan Buell, Harvard Business School, Morgan Hall 429, Boston, MA, 02163, United States, rbuell@hbs.edu, Basak Kalkanci

Across three experiments, conducted in the field and lab, we compare how transparency into internal and external social and environmental responsibility initiatives affects customer perceptions and sales. Our field evidence provides converging evidence that transparency into a company's internal responsibility practices can be at least as motivating of consumer sales as transparency into its external responsibility initiatives. We further investigate the perceptual effects of transparency into internal and external responsibility initiatives and find that the underlying psychological mechanisms linking both types of transparency to consumer purchase intentions are consistent.

3 - The Impact of Social Learning on Consumer Subsidies for Green Technology Adoption

Hang Ren, School of Business, George Mason University, Fairfax, VA, 22030, United States, hren5@gmu.edu, Tingliang Huang, Georgia Perakis

To incentivize consumer adoption of expensive green-tech products, governments typically o er consumers subsidies through rebates and tax credits. Apart from subsidies, consumers' adoption decisions are usually also influenced by the word-of-mouth information about product quality from earlier adopters. In this paper, we study a government's optimal dynamic subsidy decision in the presence of consumers' social learning.

4 - The Market Value of Sustainability Disclosure: A Cross-Cultural Field Study

Tim Kraft, Assistant Professor, North Carolina State University, Raleigh, NC, 02142, United States, timckraft@gmail.com, Markko Hamalainen, Douglas Thomas, Yanchong Zheng, Meng Zhang

Partnering with Goodio, a Finland-based craft chocolate producer, we explore how consumers react to values-based and evidence-based messaging regarding environmental and social initiatives. We test the effects of transparency in three markets (US, Finland, and Japan) with both online and field experiments.

5 - Trying and Failing: Donor Aversion to Rejection

Leon Valdes, Assistant Professor, University of Pittsburgh, Joseph M. Katz Graduate School of Business, Pittsburgh, PA, 15260, United States, lvaldes@katz.pitt.edu, Kaitlin Daniels

The outpouring of concern that follows a disaster often generates excess donations. Nonprofits routinely accept these donations, fearing that turning away donors will discourage them from donating again. We conduct an incentivized experiment to investigate whether this fear is warranted and explore the behavioral motives for not donating again. Our results show that learning about or experiencing a rejected donation decreases the estimated probability that a donation will be accepted in the future, which decreases the likelihood of donating again. Furthermore, we compare our results with a for-profit situation and show that self-serving bias plays a key role in explaining this behavior.

■ MA72

S- Columbia

Digital Platform and E-commerce

Sponsored: Information Systems

Sponsored Session

Chair: JaeHwuen Jung, Temple University

1 - The Impact of Sharing Economy on Tourism Industry

Jiyong Park, University of North Carolina at Greensboro, Greensboro, NC, 130-722, United States, jiyong.park@uncg.edu

The rapid growth of sharing economy presents opportunities to grow the tourism economy by allowing to rent one's residence to tourists and to provide transportation services in a personal vehicle. This study examines whether and how Airbnb and Uber influence tourism industry employment. Our findings demonstrate that the number of Airbnb reviews is associated with the increase in local employment of tourism industries, especially for food/beverage industries. Importantly, in low accessibility neighborhoods which are underserved by public transits, we find that Airbnb has a spillover effect on local employment in the food/beverage industries only when ride-sharing services are available.

2 - Enhancing Social Media Analysis with Visual Data Analytics: A Deep Learning Approach

Donghyuk Shin, Arizona State University, Tempe, AZ, 98109, United States

We propose a number of visual and textual content features including complexity, similarity, and consistency measures that can play important roles in the persuasiveness of social media content. We then employ state-of-the-art machine learning approaches such as deep learning and text mining to operationalize these new content features in a scalable and systematic manner. For the newly developed features, we validate them against human coders on Amazon Mechanical Turk. The proposed research framework illustrates how deep learning methods can enhance the analysis of unstructured visual and textual data for social media research.

3 - Enterprise Systems Deployment Disparity, Business Environments, and Firm Performance

Inmyung Choi, Texas Tech University, Lubbock, TX, United States, inmyung.choi@gmail.com

We examine the nuanced effect of the deployment of enterprise systems across business units on firm performance by developing the concept of enterprise systems deployment disparity (ESDD). ESDD captures the extent to which a firm allocates its enterprise systems across business units unevenly. Then, using a sample of 1,872 firm-year observations from the United States, we find that ESDD (i.e., unbalanced utilization of enterprise systems) is associated with superior financial performance. Further, we investigate the moderating role of business environments (i.e., industry dynamism, concentration, and velocity) on the relationship between ESDD and firm performance.

4 - Understanding Customer Flows in Shopping Centers Using WiFi Tracking

Changseung Yoo, Assistant Professor, McGill University, Montreal, QC, Canada, changseung.yoo@mcgill.ca

We develop a machine learning framework to help a marketing analytics company scale up its personalization for users of its WiFi services. In particular, we leverage the large amounts of data it holds to see how well our algorithms can predict individual's shopping/travel pattern. Furthermore, we uncover complementarities or substitutabilities between various location choices, which are then used to refine the personalization of landing pages upon logging onto the WiFi services.

■ MA73

S- Boren

Social Media Analytics

Sponsored: Information Systems

Sponsored Session

Chair: Yixin Lu, George Washington University, Washington, DC, 20052, United States

1 - Measuring the Impact of Crowdsourcing Features on Mobile App User Engagement and Retention

Zhuojun Gu, UT Arlington, Arlington, TX, United States

The most commonly cited issues with mobile apps are low user engagement and retention levels. In this paper, we explore the efficacy of crowdsourcing features on enhancing user engagement and retention in the context of mobile gaming apps. To do so, we examine two specific crowdsourcing features, namely, the ability to contribute content and the ability to access crowdsourced content. Under a 2×2 factorial design, we assess the impact of these crowdsourcing features on usage outcomes via a randomized field experiment.

2 - The Role of Religion in Online Prosocial Lending

Amin Asabzehz@asu.edu, Arizona State University W.P. Carey School of Business, Phoenix, AZ, United States, asabzehz@asu.edu

We propose a measure of religious distance between any given pair of countries and incorporate it to explain lending volumes in online prosocial platforms. Results demonstrate the negative effect of religious differences on lending activity. We show that the effects of religious differences vary a great deal, being moderated by the social environment characterizing both lender and borrower countries in a given time period. That is, we find that increases in the degree of social hostilities within a lender country amplifies the negative effects of religious differences on lending activity and, at the same time, diversity of religion and greater physical distances attenuate such negative effects.

3 - Brokerage Model for Online Trading Platforms: One-side or Both-side?

Peng Wang, Xidian University, Xi'an, China, wangpeng7@stu.xidian.edu.cn, Rong Du, Hongpeng Wang

Motivated by the successful practice of both-side brokerage revenue model—charging both house owners and renters—in Airbnb.com, we investigate how an online trading platform should design its brokerage model. The main results indicate that it is preferable for an online platform to charge sellers and buyers when the mass of buyers who fully value trust is larger and the cost to build the seller-side platform-enabled trust is smaller. Furthermore, we identify a tradeoff between the buyer-side net benefit and the seller-side net loss of using the both-side brokerage model. We also reveal how transaction and culture differences influence the platform's choice between the two brokerage models.

4 - A Gamification-based Study on the Effect of Information Transparency and Social Value Orientation

Xu Han, Fordham University, New York City, NY, United States

We designed a game on social media platform and conducted randomized field experiments to study how information transparency and social value orientation (SVO) will affect user behaviors. Participants are invited to play a game under different information transparency levels and pre/post-game surveys are conducted to collect demographic information and their SVO. We found different effects of imformation transparency on high/low-performance players. We also found significant impact of SVO on players' engagement. Our research demonstrates possibilities to design a mechanism to achieve overall collaborative benefits in a competitive gamification setup.

■ MA74

S- Capitol Hill

Location Analysis I

Sponsored: Location Analysis

Sponsored Session

Chair: Dmitry Krass, University of Toronto, Toronto, ON, M5S 3E6, Canada

Co-Chair: Oded Berman, University of Toronto, Toronto, ON, M5S 3E6, Canada

1 - Coordination in Emergency Response: An Application to Hazardous Materials Transportation

Vedat Verter, McGill University, Faculty of Mgmt, 1001 Sherbrooke Street West, Montreal, QC, H3A 1G5, Canada, vedat.verter@mcgill.ca, Peng Hu, Jiahong Zhao

Coordination of multiple resources involved in emergency response is largely overlooked in the literature. This requires not only the response time of each resource, but also the amount of time the teams may have to wait for each other. We present a mathematical model for simultaneously siting ambulance and fire stations. We discuss a case study on Chengdu, China.

2 - Probabilistic Set Covering Problem

Robert Aboolian, California State University-San Marcos, San Diego, CA, 92130, United States, raboolia@csusm.edu, Oded Berman, Majid Karimi

We consider a network of congested service facilities which cover customers assuming a maximum average access time to service, which is the sum of average travel, average waiting for service and average service times. The objective is to minimize overall fixed and service capacity costs so that the average access time to service does not exceed a certain level. Demand is elastic and decreasing in access time to service. These problems are usually solved using bi-level programming techniques and since demand is a function of waiting time and vice versa, we need to solve a series of equilibrium conditions in the second level. Here we develop a MIP optimization model which solves the problem in single level.

3 - Optimal Pricing, Sizing and Location for Facilities Facing Stochastic Demand

Dmitry Krass, University of Toronto, Rotman School of Management, Toronto, ON, M5S 3E6, Canada, krass@rotman.utoronto.ca, Oded Berman

We analyse the problem of determining the number and locations of the facilities, service capacity of each facility, and the prices to charge for service. Utility-maximizing customers residing at the nodes of the network generate stochastic demand streams. Customer utility is influenced by the price, travel distance and waiting times. We obtain a number of structural and algorithmic results, including nodal optimality, conditions for separability of pricing, capacity and location decisions, and near- optimality of uniform prices when customer demand is log-additive. We show how single facility results can be applied to derive optimal or near-optimal solutions for multi-facility problems.

■ MA77

S- Fremont

Latest Developments in Scheduling

Emerging Topic: Project Management & Scheduling

Emerging Topic Session

Chair: Zhi-Long Chen, University of Maryland, College Park, MD, 20742-1815, United States

1 - Coordinated Scheduling and Price Quotation with Due Dates

Zhixin Liu, University of Michigan-Dearborn, Dearborn, MI, United States, zhixin@umich.edu, Liang Lu, Xiangtong Qi

We study coordinated price quotation and scheduling for a manufacturer. Each quote for an order can be either accepted or rejected by a customer and has a due date related cost when processed. We develop an exact algorithm to calculate the expected profit under a given set of price quotations, and then design an algorithm to find near optimal price quotations. We also find an upper bound of the manufacturer's maximum expected profit. Computational study justifies the efficiency of our algorithm.

2 - Scheduling Problems with Assembly Operations in Alibaba's Hema Store

Weiya Zhong, Shanghai University, Shanghai, China, wyzhong@shu.edu.cn

Alibaba's Hema Store, provides a seamless blend of online and offline shopping experience for customers and is likely to reshape the landscape of China's retail industry. In this talk, we present a new scheduling problem in Hema Store. Each job(order) may be composed of several sub-jobs(sub-orders) . Inside the store, each sub-job is handled by a dedicated flowshop, then different sub-jobs of one job are assembled together. After the assembly operations, the jobs are delivered to their customers in different locations by multiple deliverymen. For different settings and objective values, we propose various scheduling models, analyze the time computational complexity and design heuristics.

3 - Artificial Intelligence and Machine Learning in Scheduling Research

Zhi-Long Chen, University of Maryland, Robert H. Smith School of Business, Dept of Decision, Operations & Info Tech, College Park, MD, 20742-1815, United States, zchen@rhsmith.umd.edu

This talk will take a look at existing research that applies AI or ML tools to scheduling problems.

■ MA78

S- Greenwood

Technology and Contests

Sponsored: New Product Development

Sponsored Session

Chair: Ersin Korpeoglu, University College London, London, E14 5AA, United Kingdom

1 - Green Technology Development and Adoption: Competition, Regulation, and Uncertainty – A Global Game Approach

Xin Wang, Hong Kong University of Science and Technology, Hong Kong University of Science and Technolog, IELM, Hong Kong, Hong Kong, xinwang@ust.hk, Soo-Haeng Cho, Alan Scheller-Wolf

When a government is considering tightening a standard on a pollutant, their decision often is influenced by the number of firms being able to meet the tightened standard, because a higher number indicates a more feasible standard. We study how such regulation may affect a firm's incentive to develop a new technology to reduce a pollutant. To analyze this problem, we use the global game framework recently developed in economics. We find that regulation that considers industry capability, compared with regulation that ignores it, can more effectively motivate development of a new green technology. Surprisingly, uncertainty in the payoff can also help promote development of a new green technology.

2 - How Procurement Contests Shape the Technological Landscape

Jochen Schlapp, Frankfurt School of Finance & Management gGmbH, Adickesallee 32-34, Frankfurt am Main, 60322, Germany, Jussi Keppo, Jurgen Mihm

Companies in technology-intense industries frequently engage in contest-like competition to provide customers with superior technologies. Oftentimes, the firm offering the best technology is able to reap large shares of the market. However, over time, competitors may introduce new technologies that outperform older ones and thus change the allocation of market shares. We study how the prevalence of such contest-like competition affects the competitors' technology choices over time, and whether competition leads to more desirable outcomes as compared to a monopoly market.

3 - Sourcing Innovation: Integrated System or Individual Components

Zhi Chen, INSEAD, Singapore, 138676, Singapore, zhi.chen@insead.edu, Jurgen Mihm, Jochen Schlapp

Many purchasing projects involve buying complex systems, which require the suppliers to perform some custom product or technology development regardless of whether they win the project or not. Viewing such a procurement setting through the lense of contest, we study under which circumstances a buying firm should source an integrated system or individual components.

4 - The Role of Participation in Innovation Contests

Konstantinos I. Stouras, UCD Smurfit, Dublin, Ireland, Jeremy Hutchison-Krupat, Raul Chao

We study how to design an innovation contest when solvers have a participation decision.

■ MA79

S- Issaquah A

Sustainable Electricity Demand

Emerging Topic: Sustainable Growth

Emerging Topic Session

Chair: Zana Cranmer, Bentley University, Waltham, MA, 02452, United States

1 - Characterizing the Uncertainty on Future Residential Electricity Demand in China

Dalia Patino Echeverri, Associate Professor of Energy Systems and Policy, Duke University, Nicholas School of the Environment, Box 90227, Durham, NC, 27708, United States, dalia.patino@duke.edu

We project residential electricity demand in China under varying socioeconomic, technical and climate conditions. Adoption of electric appliances is estimated for forty-five scenarios that combine five levels of population growth, three levels of per-capita gross domestic product (GDP) and income growth, and three levels of change in household size. The population scenarios are generated with a province-specific cohort-component model that accounts the increase of life expectancy, the gradual balancing of the sex ratio at birth, and five plausible trends in fertility rate. Scenarios for time-of-use of appliances are based on a characterization of consumer types based on a household survey.

2 - Domain-constrained Statistical Inference from Sensor Data in Modern Buildings

Mario Berges, Professor, Carnegie Mellon University, Pittsburgh, PA, 15213, United States

Though our buildings are being covered with sensors and computing devices at an incredibly fast rate, and we have developed highly-flexible and efficient mathematical models to make sense of all the data that these devices are generating, our ability to make use of these two advances in the context of buildings is limited compared to other fields (e.g., computer vision). Broadly speaking, this is because of the lower data availability and because physics imposes more difficult constraints on the learning problem. Here I will discuss how to incorporate domain-expertise to improve our ability to perform (approximate) inference in two such settings: electricity disaggregation and HVAC control.

3 - A Portfolio Model for Energy Efficiency Projects

Zana Cranmer, Bentley University, Waltham, MA, 02452, United States, acranmer@bentley.edu

What are the best energy efficiency projects for commercial organizations to pursue? This work develops a portfolio model to help organizations determine the most valuable energy efficiency projects across their building stock. The model accounts for institutional constraints such as capital budgets, the interactions between projects, and uncertainty in project costs and performance. An organization's optimal strategy (set of energy efficiency projects) will depend on the building stock and how the buildings are used.

4 - Evaluating the Sustainability of Energy Pathways with a Multi Criteria Decision Analysis Approach: A Case Study on Mexico

Rodrigo Mercado Fernandez, University of Massachusetts Amherst, 65 McClellan Street, Amherst, MA, 01002, United States

This paper examines the use of multi criteria decision analysis (MCDA) to evaluate the sustainability of different expansionsin the Mexican Electrical Grid.In particular, we will include the transmission, and generation networks into the evaluation of sustainability for each pathway. We use a set of social, economic and environmental criteria to evaluate the sustainability of each expansion plan up to 2050. The goal will be to use the insight of the sustainability of each expansion plan to better inform decision maker in developing energy policy.

■ MA80

S- Issaquah B

Empirical Research in Innovation and Entrepreneurship I

Sponsored: Technology, Innovation Management & Entrepreneurship

Sponsored Session

Chair: Panos Markou, Cambridge Judge Business School, Cambridge, CB2 1AG, United Kingdom

1 - Perils of Bargaining Power in R&D Licensing

Niyazi Taneri, National University of Singapore, NUS Business School, Singapore, 119245, Singapore, niyazi@nus.edu.sg, Arnoud De Meyer

License agreements present opportunities for innovators (licensors) and their partners (licensees) to leverage each other's complementary capabilities. It is natural for a firm to use a position of higher relative bargaining power for its potential gain but this can lead to a misalignment of incentives: An innovator with higher relative bargaining power may push for higher deal value but a partner facing higher payments at a continuation decision may prioritize other projects in its portfolio. We investigate how deal value is determined and how deal value — and its underlying drivers — influence downstream terminations.

2 - Invention Integrality and Gender Composition in Innovation Teams

Wenjie Tang, National University of Singapore-Business School, Singapore, 119245, Singapore, wenjie.tang@nus.edu.sg, Tian Chan, Haibo Liu, Steffen Keck

When do teams with female member(s) create more valuable innovations than do all-male teams? We theorize that this will be so when the invention is integral, i.e., hard to decompose into chunks amenable to independent efforts. Using utility patent data from 1985 to 2015, we show that, whereas innovation teams with at least one female member tend to generate patents of similar market value (compared to all-male teams) on the average, such teams outperform when the invention is integral. We undertake a laboratory experiment and confirm our prediction that the positive effect of female members on a team's output is explained by a higher level of psychological safety as compared to all-male teams.

3 - Sequential Decision Making: Biases and Heuristics

Evgeny Kagan, Johns Hopkins Carey Business School, Baltimore, MD, United States, Ozge Sahin, Stephen Leider

Many innovation and product development processes involve human decisions that are made sequentially, as new information is being revealed. In this paper we explore theoretically and experimentally decision biases in this setting, looking in particular at what decision policies humans adopt. We find support for a particular class of decision policies that deviate from the optimal policies in non-trivial, but predictable patterns.

4 - Exploring the Impact of Organizational Sponsorship on the Entrepreneurial Journey of Start-ups

Stylianos Kavadias, Margaret Thatcher Professor of Innovation & Growth, University of Cambridge, Judge Business School, Trumpington Street, Cambrige, CB2 1AG, United Kingdom, s.kavadias@jbs.cam.ac.uk, Keivan Aghasi

Start-up companies suffer from limited legitimacy and low social capital endowment, which make it difficult for them to gain access to vital information and other relevant resources, necessary for them to grow. Support programmes offer organisational sponsorship to them to help overcome these challenges. Our paper uses a unique sample of 1320 nascent ventures that have applied to Pitch@Palace - a well known support programme in the UK - to measure and validate the effect of such sponsorship on different dimensions of entrepreneurial performance. We show how the effect is contingent on the prior-to-entry status of the start-up.

■ MA81

S- Kirkland

Forestry V: Biodiversity Conservation Planning

Sponsored: Energy, Natural Res & the Environment/Forestry

Sponsored Session

Chair: Bistra Dilkina, University of Southern California, Los Angeles, CA, 90089, United States

Co-Chair: Robert G Haight, US Forest Service, Saint Paul, MN, 55108, United States

1 - The Cost of Institutional Hierarchies in Spatial Conservation Planning

Bistra Dilkina, University of Southern California,Los Angeles, CA, 90089, United States, bdilkina@gmail.com

We study how institutional constraints that limit how freely conservation funding can be moved around impact the biodiversity gains available from habitat protection programs. We present a hierarchical optimization framework, based on a mixed-integer bi-level model, that can account for differences between conservation actors regarding what aspects of biodiversity they most value. Through large-scale case studies, we evaluate the cost of ignoring institutional structure in spatial planning tools in terms of an over-estimation of possible conservation gains.

2 - A MIP Approach for Multi-action Planning for Threat Management

José Salgado, Phd Student, Forest Sciences Centre of Catalonia (CTFC), Solsona, Spain, jose.salgado@upc.edu, Jordi Garcia-Gonzalo, Virgilio Hermoso, Eduardo Álvarez-Miranda, Andrés P. Weintraub

This paper discusses multi-objective integer programming optimization models for designing conservation plans. The proposed models allow the dsicussion of trade-offs between ecological benefits, implementation cost and fragmentation of the area that is monitred or where actions are carried out.

3 - Optimizing Camera Trap Placement Designs for Species Density Estimation

Amrita Gupta, Georgia Institute of Technology, Atlanta, GA, United States, gupta.amrita20@gmail.com, Bistra Dilkina

Camera traps are becoming an increasingly widespread tool for wildlife ecologists that allows them to collect photo capture data that is then used as presence/absence information in species density estimation or habitat suitability estimation. Most studies use a simple grid design for the placement of the sensors. Prior research has shown that trap configuration and spacing influences parameter estimates in Spatial Capture-Recapture models. We investigate how one can optimize the design of the camera trap placement across the landscape to maximize the utility of the collected data and leverage any prior information about the species or the habitat.

■ MA82

S- Leschi

Joint Session ENRE/Elec/Practice Curated: Addressing Computation and Market Integration Challenges in Power Systems

Sponsored: Energy, Natural Res & the Environment/Electricity

Sponsored Session

Chair: Murat Yildirim

Chair: Paritosh Ramanan, Georgia Institute of Technology, Atlanta, GA, 30324, United States

1 - Decentralized Multithreaded Maintenance for Large Scale Power System Planning Problems

Paritosh Ramanan, Georgia Institute of Technology, Atlanta, GA, 30324, United States, paritoshpr@gatech.edu

In this talk we present a decentralized solution framework for the maintenance and operations problem for large scale power networks based on streaming sensor data from assets based on a region based decomposition with the help of MPI. Within a region, we decouple the maintenance and operational problems by the week and exploit multithreading to make the combined long term problem tractable. A two phase algorithm is proposed that relies on the convex relaxation and privacy preserving valid inequalities in order to deliver algorithmic improvements. We show that our decentralized method delivers a superior computational performance as compared to the state of the art centralized method.

2 - Integrating Degradation Sensor Data to Electricity Markets

Farnaz Fallahi, Wayne State University, Detroit, MI, United States, gc5019@wayne.edu, Murat Yildirim, Jeremy Lin

Degradation sensor data enables new tools to monitor and control generation assets in power systems. These tools are typically used in engineering applications: i.e. detection of failure risks across the grid. In this talk, we develop a unified market framework for operations and maintenance (O&M) scheduling that adapts to real-time degradation sensor data. The proposed approach identifies optimal adaptive O&M bidding decisions of generation companies (GenCos) based on their sensor data and studies the impact of these adaptive decisions on the efficiency of the electricity markets. The proposed framework provides revenue opportunities to GenCos, and significantly improves grid reliability.

3 - Primal Heuristics for Unit Commitment with Transmission Switching

Emma S. Johnson, Georgia Institute of Technology, Atlanta, GA, 30309, United States, Shabbir Ahmed, Santanu Subhas Dey, Jean-Paul Watson

State-of-the-art unit commitment formulations are tight enough that, when we add transmission switching, the dual bound is in practice very good. The difficulty lies in finding quality primal solutions. We propose heuristics for finding primal switching solutions for both DC optimal transmission switching and for unit commitment with transmission switching. On the assumption that this is a problem which is solved often, we utilize solutions from already-solved related instances to generate solutions to a new instance. We compare to switching heuristics in the literature based on dual information from DC optimal power flow.

4 - Market-based Resource Adequacy Assessment under High Variable Renewable Resource Penetrations

Jonghwan Kwon, Argonne National Laboratory, 4808482924, Lemont, IL, 60439, United States, Kwonj@anl.gov, Zhi Zhou, Todd Levin, Audun Botterud

We will present a market-based resource adequacy assessment framework that captures the strategic capacity investment and retirement decision-making of profit-maximizing generation companies. The model is based on Stackelberg leader-follower games and is formulated as a bi-level optimization problem. Furthermore, we employ a Lagrangian decomposition algorithm and parallel computing to enhance computational performance. We will demonstrate the value and the potential application of the modeling framework with a case study.

■ MA83

S- Medina

Equilibrium Models in Energy I

Sponsored: Energy, Natural Res & the Environment/Electricity Sponsored Session

Chair: Simon Risanger, Norwegian University of Science and Technology (NTNU), 5542, Norway

Co-Chair: Steven Gabriel

1 - Inverse Equilibrium Analysis of Oligopolistic Electricity Markets

Simon Risanger, Norwegian University of Science and Technology, Stenderv. 65, Trondheim, 5542, Norway, simon.risanger@ntnu.no, Stein-Erik Fleten, Steven A. Gabriel

Equilibrium models are extensively used to investigate electricity market problems. Input parameters that represent market participants, such as costs or willingness-to-pay, are crucial to produce reasonable output for further analysis. However, these parameters are often unobservable and can be challenging to obtain. Equilibrium outcomes, such as market prices and volumes, on the other hand, are directly observable. We present inverse equilibrium models that use observations from market outcomes as input in order to estimate objective function parameters.

2 - Capacity and Energy Market Equilibria: Storage Load Carrying Capability and Unit Commitment Representation

Benjamin Field Hobbs, Schad Chaired Professor, Johns Hopkins University, Baltimore, MD, 21218, United States, bhobbs@jhu.edu, Shen Wang, Cynthia D. Bothwell

A capacity and energy market equilibrium model is used to identify the appropriate capacity credit (effective load carrying capability) to give to storage, demand response, and generation technologies, given unit commitment constraints and variable output of renewable generation. A capacity market simulation model shows the impact of giving inaccurate credit to different resource sin the market. The model considers multiple years of demand and variable renewable hourly realizations, but assumes perfect foresight in commitment and storage decisions.

3 - Market Equilibria and Interactions Between Strategic Generation, Wind, and Storage

Ramteen Sioshansi, The Ohio State University, Department of Integrated Systems Engineering, Columbus, OH, 43210-1271, United States, sioshansi.1@osu.edu, Antonio J. Conejo

Many electricity markets are seeing increasing penetrations of weather-dependent renewable generators and energy storage. This talk provides a modeling framework that can be used to examine how these types of assets interact with conventional generators in a market environment. Different asset-ownership and market structures will be compared in terms of market outcomes and efficiency.

4 - Equilibria in Electricity and Natural Gas Markets with Strategic Offers and Bids

Antonio J. Conejo, The Ohio State University, Department of Integrated Systems Engineering, Columbus, OH, 43210, United States, conejo.1@osu.edu, Sheng Chen, Ramteen Sioshansi

We study market equilibria achieved by strategic firms that participate in electricity and gas markets. These firms submit their offers and bids to both markets with the aim of maximizing profit or utility and consider firms that can include combination of electricity and gas supply and demand. The strategic actions of these firms are represented by upper-level problems that are optimized subject shared lower-level problems that represent the clearing of electricity and gas markets. We develop a solution methodology that allows us to find equilibria with different characteristics.

■ MA84

S- Ravenna A

Equilibrium Models in Energy

Contributed Session

Chair: Felipe A. Feijoo, Pontificia Universidad Católica de Valparaíso, Av. Brasil 2241, Office 6-8, Valparaíso, Chile

1 - Combining Scenario Foresight and a Convex-quadratified MCP for Futures of Energy, Climate, and Policy

Dawud Ansari, DIW Berlin, Berlin, Germany, dansari@diw.de, Franziska Holz

This study presents four novel and multidisciplinary scenarios of energy, climate, and policy. They overcome previous barriers by combining qualitative and quantitative methods: First, we use structured analytic techniques to generate storylines, including a facilitated expert workshop. Then, we calibrate the energy and resource model Multimod to reflect the different storylines. In this, the study is the first major application of Baltensperger, Egging, and Tomasgard (2018): We cut computation time by 99.8% by reformulating Multimod, a mixed complementarity problem, into a convex-quadratic problem. Finally, we unite and refine storylines and model results into holistic narratives.

2 - Regulatory Competition: Discovering Strategic Energy Policy via EPECs

Jip Kim, New York University, Brooklyn, NY, United States, jipkim@nyu.edu, Yury Dvorkin

State regulatory bodies can exhibit strategic behavior to advance their energy policy goals at the expense of neighboring jurisdictions, which are connected via a transmission network. This talk describes the effects of this strategic behavior on the transmission-distribution interactions and state renewable portfolio standards using Equilibrium Problems with Equilibrium Constraints (EPEC). This EPEC accounts for operating and planning uncertainties, which are typical for power system expansion studies, using chance constraints. The case study is carried out for the 8-zone ISO-NE system.

3 - A Bilevel Approach to Optimize Electricity Price in Local Energy Transaction Market

Xiaochun Feng, Northwest A&F University, Yangling, China, Yang Chen

Along with the rising two-way communication smart grid technologies and distributed renewable energy, energy trading among neighborhood prosumers has been gained more and more attention, and local energy transaction market starts to be emerged. To better investigate the price-demand relationship for this local market operator (LMO) equipped with PV and energy storage, a bilevel optimization model is proposed where the goal is to optimize operation profit for LMO at upper level and bill payment for customers at lower level. Experimental results have shown that more cost savings and energy sharing level could be achieved.

4 - Trilevel Models and Reformulations for Preventing Tacit Collusion in Electricity Markets

Murat Elhuseyni, Sabanci University, Istanbul, Turkey, muratelhuseyni@sabanciuniv.edu, Guvenc Sahin, Emre Celebi

We consider a collusion model for competitive pool based electricity markets operated by an independent system operator (ISO), which aims to prevent tacit collusion among generators by changing market and network parameters. We have formed a game-theoretic model to represent the market clearing mechanism, where generators determine their bids in order to maximize their profit while ISO allocates power and determine locational marginal prices. The ISO's collusion prevention leads to a trilevel problem, which is already complex and difficult to solve. We provide equivalent reformulations and linearization methods to obtain results with reasonable computational time.

■ MA85

S- Ravenna B

Advances in Large-Scale and Distributed Energy Generation

Sponsored: Energy, Natural Res & the Environment/Energy Sponsored Session

Chair: Alexandra M. Newman, Colorado School of Mines, Golden, CO, 80401, United States

1 - Optimal Policies for Dispatchable Solar Hybrid Energy

Phillip Buelow, Colorado School of Mines, Main Campus, Golden, CO, 80401, United States, pbuelow@mymail.mines.edu, Alexandra M. Newman

Concentrated solar power (CSP) towers are an emerging technology that utilize molten salt thermal energy storage to dispatch electricity during peak-market-priced hours. Hybridization of CSP, photo-voltaics (PV) and lithium-ion batteries offers a stable, price-competitive alternative to conventional grid-level energy production when informed by a mixed-integer linear program (MILP). The CSP-PV hybrid system's maximum effectiveness relies on an optimal operational and dispatch policy. We explore that MILP model's strategy and the impacts of subsystem design, environmental location, and component cost on the economics and policy regarding renewable energy market penetration.

2 - Optimizing Mirror-washing Assignments for Concentrating Solar Power Central Receiver Plants

Jesse Wales, Colorado School of Mines, Golden, CO, 80401, United States, jwales@mymail.mines.edu, Alexander Zolan, Alexandra M. Newman, Michael J. Wagner

Concentrating solar power central receiver plants use thousands of sun-tracking mirrors to reflect the heat from sunlight to a central receiver, which is collected and used to generate electricity. Over time, soiling reduces the reflectivity of the mirrors and, therefore, the efficiency of the system. We present a mixed-integer linear program that assigns wash crews to mirrors to minimize the sum of (i) the revenues lost due to soiling, (ii) the costs of hiring full-time and seasonal wash crews, and (iii) the costs of purchasing wash vehicles.

3 - Generation and Transmission Planning with Decentralized Distributed Resource Decision Making

Nan Zhang, PhD Student, The University of Texas at Austin, Austin, TX, United States, Juan Pablo Carvallo, Benjamin Leibowicz, Peter Larsen, Sean Murphy

Increasing deployment of distributed resources is challenging traditional power sector planning paradigms. In this paper, we formulate and implement an integrated generation and transmission planning model that separates distributed resource investment and dispatch decisions from centralized, utility-scale decisions. We focus on a single electric utility as a case study and experiment with different decision making structures, sequences of player decisions, and retail rate structures.

4 - Capacity Expansion Problem Considering Reserve Provision by Wind Power and Storage Units

Miguel Carrión, Universidad de Castilla-La Mancha, Toledo, Spain, Miguel.Carrion@uclm.es, Miguel Cañas-Carretón

The active participation of wind power units in the ancillary services has increased significantly during the last years. Considering this, we formulate a capacity expansion problem considering that wind power units and storage facilities are able to provide reserve. To this end, we assume that wind power units can follow a maximum power point track strategy or a deloaded one. The uncertainty associated with wind speed forecast is also considered. The proposed formulation is tested on a realistic case study that is based on an actual isolated power system in Spain.

5 - Optimal Sizing of a Hybrid Energy Storage System Operated on a Microgrid Using Climate Data Analytics

Fei Sun, Graduate Research Assistant, Texas state university, San Marcos, TX, United States, f_s38@txstate.edu, Tongdan Jin, Clara Novoa

The optimal sizing of a microgrid system that integrates Li-ion battery and supercapacitor is studied. The objective is to minimize the system investment and operating cost. The reliability criterion and time-of-use rate scheme are considered to achieve the carbon neutral goal. The hybrid system provides high energy density capacity to store renewable energy and smooths the quick fluctuations of load with high power density.

■ MA86

S- Ravenna C

Energy System Optimization

Sponsored: Energy, Natural Res & the Environment/Energy

Sponsored Session

Chair: Kai Pan, Hong Kong Polytechnic University, Kowloon, Hong Kong

1 - EGRET: Electrical Grid Research and Engineering Tools

Bernard Knueven, Sandia National Laboratories, Albuquerque, NM, 87185-1326, United States, Michael Lee Bynum, Anya Castillo, Carl Laird, Jean-Paul Watson

EGRET is a Python-based package for electrical grid optimization based on the Pyomo optimization modeling language. EGRET is designed to be friendly for performing high-level analysis (e.g., as an engine for solving different optimization formulations), while also providing flexibility for researchers to rapidly explore new optimization formulations. This talk will focus on EGRET's unit commitment capabilities.

2 - The Future of Natural Gas Infrastructure in North America

Sauleh Ahmad Siddiqui, Johns Hopkins University, Baltimore, MD, 21218, United States, siddiqui@jhu.edu, Charalampos Avraam, Felipe A. Feijoo, Gokul Iyer

Low-cost supply from shale gas production along with the transition to a low-carbon economy has led to natural gas becoming the main fuel for electricity production in North America, and the leading source for electricity production in both the United States. In this presentation, we will examine inter-state natural gas pipeline infrastructure development in the US under different long-term socioeconomic scenarios by coupling the Global Change Assessment Model (GCAM-USA), an integrated assessment model, with NANGAM.

3 - On the State of the Art in Stochastic Unit Commitment: Software, Algorithms, and Challenges

Jean-Paul Watson, Sandia National Laboratories, Livermore, CA, 87113-2065, United States, jwatson@sandia.gov

Over the past decade, researchers have made significant progress toward modeling and solving industrial-scale stochastic unit commitment problems in operational run times. In this talk, we outline key advances over this period, and discuss recent research by the speaker and his collaborators.

4 - Tight-and-cheap Conic Relaxations for AC Optimal Power Flow and Optimal Reactive Power Dispatch

Miguel F. Anjos, University of Edinburgh, School of Mathematics, James Clerk Maxwell Building, Edinburgh, EH9 3FD, United Kingdom, anjos@stanfordalumni.org, Christian Bingane, Sébastien Le Digabel

The classical alternating current optimal power flow problem is nonconvex and generally hard to solve. We propose a new conic relaxation obtained by combining semidefinite optimization with RLT. The proposed relaxation is stronger than the second-order cone relaxation, nearly as tight as the standard semidefinite relaxation, and up to one order of magnitude faster than for the semidefinite chordal approach on benchmarks with up to 6515 nodes. We extend the approach to optimal reactive power dispatch with similar results and performance.

5 - Coordinating Electricity and Gas Markets

Kai Pan, Hong Kong Polytechnic University, M507a, 5/F, Li Ka Shing Tower, Kowloon, Hong Kong, kai.pan@polyu.edu.hk, Ming Zhao, Chung-Lun Li, Feng Qiu

We consider an independent power producer (IPP) that uses natural gas to generate electricity and participates in the wholesale electricity market. Optimal policy for the IPP to coordinate the electricity and gas markets are derived. Extensive case studies are conducted to show algorithmic efficiency and managerial insights.

■ MA92

S- Grand Ballroom A

Supply Chain Management V

Contributed Session

Chair: Abhishek Roy, Temple University, Fox School of Business, Philadelphia, PA, 19122, United States

1 - The Effect of Flexibility on the Benefits of Sales and Operations Planning

Juan Antonio Cedillo, Instituto Tecnológico y de Estudios Superiores de Monterrey, Monterrey, NL, Mexico, A00997352@itesm.mx, Neale R. Smith, González-Ramírez Rosa G.

Ongoing research in Sales and Operations Plannning focuses on the ability of companies to respond to demand uncertainty. This paper proposes a mathematical model to evaluate the quantitative relation between demand forecast error and flexible capacity of a production system by evaluating their impact on plan performance. In order to prove its usefulness, the model was applied to a make-to-order system. Preliminary results are presented.

2 - Production Time Variation Coordination in Prefabricated Construction

Yue Zhai, Beijing Jiaotong University, Beijing, China, zhaiyue@bjtu.edu.cn, Xiang Fang, Linjing LI

An on-site production time variation reduction (OPTVR) coordination is studied between a general contractor (GC) and a building contractor (BC). In order to entice the BC to adopt the OPTVR strategy, a buffer space hedging (BSH) method is offered by the GC. The BSH is to reserve more spare space at an intermediate warehouse serving for contingency usage. It can be an incentive to the BC, for site congestion always happens and causes serious project time and cost overrun. A Nash game and a BC leaded Stackelberg game are investigated. It is demonstrated that these two models successfully reduce the OPTVR amount while enable a win-win outcome.

3 - Social Media Trend Analysis for Fashion Supply Chain

Olena Rudna, Rutgers University, Newark, NJ, United States, omr20@rutgers.edu

An accurate demand planning is among the biggest challenges for fashion apparel companies. Fashion buyers have to forecast sales for their products on a near real-time basis (a very short lead time) and also with a very limited amount of data (due to the short selling season of the related to forecasting demand data). In order to reduce uncertainty in demand planning while minimizing product obsolescence, we propose to utilize fashion trend information derived from online social network such as Twitter and embed it to forecasting models to strengthen prediction accuracy.

4 - Equilibrium Production Decisions for Multi-firms Considering Consumers' Quality Preference

Xin Liu, Elon University, Elon, NC, United States, xliu3@elon.edu, Xiaoya Han

In this study, we consider multiple firms competing non-cooperatively in a market under the consideration of consumers' diversified preferences for product quality. We model the problem to investigate equilibrium production decisions of these firms and explore the effect of consumer quality preference on their decisions.

5 - Trust in Supply Chain with Double Marginalization

Xianghua (Jason) Wu, College of business, University of Texas-Arlington, Arlington, TX, United States, xianghua.wu@mavs.uta.edu, Kay Yut Chen

We examine the role of information sharing, as well as the roles of trust and trustworthiness in a setting that captures both of the double marginalization (DM) and capacity misaglinment (CM) problem. We first characterize information sharing's trade-off between these two problems. Secondly, we employ the trust-embedded model and find that, similar to information sharing, trust is not always beneficial to the supply chain. Similarly, we characterize the trade-off between too little, and too much trust. However, the most counter-intuitive result is that an untrustworthy retailer can manipulate a trusting supplier, which reduces the double marginalization problem, and benefits the supply chain.

6 - Seeking the Value in Leftovers: An Analysis of the Procurement and Pricing Decisions Involving Stock-lots

Abhishek Roy, Temple University, Fox School of Business, Philadelphia, PA, 19122, United States, abhishek.roy@temple.edu, Vishwakant Malladi, Changseung Yoo

Low and medium-sized merchants often seek to buy stock-lots, or merchandise from liquidation lots, which have the potential to provide a "great bargain", as well as an environment-friendly way to reduce wastage. The stock-lots sellers use this channel to liquidate excess finished goods inventory, lower quality products, returns, as well as work-in-progress inventory. Because of the non-traditional nature of the channel, the quality of supply, and the customers' demand, are both uncertain, and the cost of carrying inventory is very high. Departing from the usual newsvendor assumptions, we analyze the merchant's strategic procurement and pricing decisions under such both-sided uncertainties.

■ MA93

S- Grand Ballroom B

Information Systems I

Contributed Session

Chair: Francesco Balocco, Erasmus University, Rotterdam, 3011ZX, Netherlands

1 - Marketing the Cloud

Xianrong Zheng, Old Dominion University, Norfork, VA, United States, x1zheng@odu.edu

As cloud services become increasingly popular, cloud providers compete to offer the same or similar services over the Internet. Quality of Service (QoS), which describes how well a cloud service is performed, will be more important. QoS refers to nonfunctional properties of cloud services, and is an important differentiator among functionally equivalent cloud services. As a result, how to use QoS to differentiate and market cloud services becomes an important topic in both IT and business disciplines. We review the state of the art, report our latest work, and discuss future research directions and challenges on the topic.

2 - How It Business Spanning Capability Moderates the Effects of It Infrastructure Capabilities on Organizational Agility

Jinlong Zhang, Huazhong University of Science and Technology, Wuhan, China, Peiran Gao

Please check the mobile app for this abstract.

3 - Two-sided Adverse Selection and Bilateral Reviews in the Sharing Economy

Murat M. Tunc, PhD Student, University of Texas-Dallas, Richardson, TX, United States, murat.tunc@utdallas.edu, Huseyin Cavusoglu, Srinivasan Raghunathan

Online peer-to-peer platforms elicit relevant information from and also disclose the information to the market participants by adopting bilateral review schemes. Although the bilateral review scheme has its own merits in reducing information asymmetry, its impact on the various stakeholders remains unexplored. We show that the bilateral review scheme intensifies price competition among service providers to attract low-cost consumers and reduces the platform's profit. Interestingly, service providers may be better off when the proportion of low-cost consumers is sufficiently high. More importantly, we find that social welfare is not always higher under the bilateral review scheme.

4 - Lemonads: Impression Quality in Programmatic Advertising

Francesco Balocco, Rotterdam School of Management-Erasmus University, Rotterdam, Netherlands, balocco@rsm.nl, Ting Li

Advertisers and publishers typically transact through Reservation contracts, Real Time Bidding (RTB), or a mixture of the two. The co-existence of multiple transaction methods is problematic since impression quality is difficult to assess. We use viewability as a proxy for impression quality. We show that publishers who engage in both Reservation Contracts and RTB offer higher quality impressions through Reservation Contracts while allocating the remaining lower quality impressions to RTB. By doing so, publishers can leverage on asymmetric information on impression quality to extract excess profit from advertisers.

■ MA94

S- Grand Ballroom C

Operations Management I

Contributed Session

Chair: Qiaohai Hu, University of Missouri

1 - Improving Personnel Management Decisions through IT Platforms and Data Analytics

Constantine Moros, Director - Advisory Services, E Y. (Ernst & Young) - Advisory Services, Athens, Greece, kmoros76@gmail.com

Managing workforce, one of the most critical resources for organizations operating within service industries, is undoubtedly becoming more challenging and complicated as technological advancements are accelerating and subsequently competition is growing. This practitioner article provides a conceptual framework and methodology for measuring, assessing and planning workforce capacity utilization in a more accurate and dynamic way,where operational research, data analytics and relevant IT transformation opportunities are exploited with the end-target of optimizing workforce productivity and efficiency levels.

2 - Price Information Asymmetry in Agricultural Contract Farming

Sreehari Karnam, Indian Institute of Management, Indore, India, f15sreeharik@iimidr.ac.in, Hasmukh Gajjar, Bhavin J. Shah

Despite very little success rate, contract farming still has been a growing practice in many countries as this practice protects both the food processing companies and the farmers from the uncertainties of supply and price. However, in the processed food sector, the processing companies who contract with farmers are exploiting the farmers by paying less to the farmers for the raw material (crop) and gaining more by selling the end product at a higher price. Due to this information asymmetry of end product prices, the farmers being unaware of the prices, unable to bargain, are exploited by not paying in the proportion of end product prices which needs further analysis to seek modeling solutions.

3 - Location Model for Cultural Facilities with the Consideration of Equity and Efficiency

Chaesung Lee, Kyungpook National University, Daegu, Korea, Republic of, cotjd3247@knu.ac.kr, Sukran Kim, Jaewoo Chung

This paper proposes a bi-criteria location model that uses spatial equity and efficiency as the criteria for public cultural facilities based on Getis-Ord Local G statistic and Gravity Model respectively. Clusters of cultural facilities such as museums and art galleries have synergies through a positive association for higher efficiency. Also, given the investment of huge public funds into public cultural facilities, the issue of social equity is important. The results of this study suggest that optimal location for cultural facilities serve as a catalyst for urban regeneration and achieving sociality.

4 - A Case Study of Demand Forecasting with Data Mining Methods for New Short-life-Cycle Products

Rie Gaku, Momoyama Gakuin University, Osaka, Japan, r-gaku@andrew.ac.jp, Soemon Takakuwa, K. Louis Luangkesorn

A major challenge for suppliers of small retail stores is how to improve a turnover rate of merchandise during a set period of time, and how to continue efforts to both ensure the availability of popular products as well as having a variety of product to satisfy multiple customer demand segments. Forecasts of product demand over its life cycle are needed for the production control system, end-of-life planning, and planning of product cycles during operational planning. This paper conducted a case-study of demand forecasting with Data Mining methods for new short-life-cycle products aiming to presenting how forecasting results can be incorporated into the operational planning process.

5 - Capacity Investment and Innovation with Renegotiation

Qiaohai Hu, University of Missouri-St. Louis, St. louis, MO, United States, huqiao@umsl.edu

This paper identifies initial contracts to induce the supplier to choose the first-best capacity investment and innovation decisions when it anticipates possible ex-post renegotiation with the buyer. Neither advance quantity commitment contracts nor price contracts yield the first-best decisions. The supplier will over-invest in cost reduction but under-build the specialized capacity under the quantity-only contract, whereas it will under-invest but over-build the specific capacity under the price-only contracts. There exist a quantity-and-price contract and a schedule of options contracts that align the supplier's interest with the channel's with or without ex-post renegotiation.

■ MA95

S- Grand Ballroom D

Funding Opportunities for OR/MS Research

Sponsored: Minority Issues

Sponsored Session

Chair: Trilce Encarnacion, Rensselaer Polytechnic Institute, Troy, NY, 12180, United States

Moderator

Trilce Encarnacion, Rensselaer Polytechnic Institute, Jonsson Engineering Center # 4049, Troy, NY, 12180, United States, encart@rpi.edu

This panel will explore a variety of opportunities for funding your OR/MS research. Lessons learned and best practices to increase your funding success will be shared.

Panelists

- Alexandra Medina-Borja, NSF/ UPRM, Falls Church, VA, 22046, United States
- Georgia-Ann Klutke, National Science Foundation, Arlington, VA, 22230, United States

Monday, 10:00AM - 10:50AM

■ Plenary

CC- Room 6E

The Parametric Self-Dual Simplex Method — A Modern Perspective (Omega Rho Distinguished Lecture)

Emerging Topic: Plenary

1 - The Parametric Self-Dual Simplex Method – A Modern Perspective

Robert J. Vanderbei, Princeton University, Operations Research & Financial Engineering, Princeton, NJ, 08544, United States

The parametric self-dual simplex method (PSD) dates back to George Dantzig's classic book published in 1963. Other variants of the simplex method have dominated the world of optimization over the years but the PSD variant has lots of attractive features both from an educational perspective and in the world of applications. In the talk I will define the method, discuss how it helps one understand more deeply duality theory and algorithm complexity and I will discuss some application areas including portfolio selection problems and LAD-Lasso problems that arise in modern machine learning problems.

Monday, 11:00AM - 12:30PM

■ MB01

CC- Room 201

Data Mining for Sustainable Supply Chain Management

Sponsored: Data Mining

Sponsored Session

Chair: Maxim Dulebenets

1 - Understanding the Major Factors Affecting Emergency Evacuation Efficiency via Driving Simulation

Maxim A. Dulebenets, Florida A&M University-Florida State University, Tallahassee, FL, 32311, United States, mdlbnets@gmail.com, Olumide Abioye, Eren Erman Ozguven, Ren Moses, Walter Boot, Thobias Sando

Evacuation planning is an essential part of natural hazard preparedness, especially in hazard-prone areas. This study aims to fill the existing gap in the state-of-the-art by investigating the effects of a wide range of different factors on the travel time, lane deviation, crash occurrence, collision speed, average acceleration and brake pedal pressure of individuals under emergency evacuation. A set of statistical models is developed to identify the most significant factors that influence the aforementioned indicators. These models are tested using the driving simulator data.

2 - Assessing the Effects of Emergency Evacuation on Vulnerable Population Groups Using a Driving Simulator

Maxim A. Dulebenets, Florida A&M University-Florida State University, Tallahassee, FL, 32311, United States, mdlbnets@gmail.com, Olumide Abioye, Eren Erman Ozguven, Ren Moses, Walter Boot, Thobias Sando

A frequent occurrence of natural hazards underlines the importance of efficient hazard preparedness, especially in the areas with aging adults. The present study proposes a set of statistical models, developed based on driver characteristics, evacuation route characteristics, driving conditions, and traffic characteristics. The required data are collected using a driving simulator and a diverse group of participants with various socio-demographic characteristics. Mental demand, physical demand, frustration of evacuees, and other important indicators are captured by the proposed models.

3 - "Factory-in-a-Box": Towards Intelligent Manufacturing and Supply Chain Management

Maxim A. Dulebenets, Florida A&M University-Florida State University, Tallahassee, FL, 32311, United States, mdlbnets@gmail.com, Hui Wang, Zhengqian Jiang, Junayed Pasha

As the market demand becomes more diversified, the requirements for manufacturing systems feature a high degree of flexibility and short delivery times. One emerging way is "factory-in-a-box," by which manufacturing modules are transported by vehicles for on-site production. This study presents a model to jointly characterize the topology of supply chain network and subassembly planning. A mathematical model is formulated for the concurrent optimization of subassembly planning and supply chain network. Potential applications and advantages of the proposed methodology are discussed.

4 - Multi-Objective Heuristic Algorithms for Planning Emergency Evacuation in Areas with an Aging Population

Maxim A. Dulebenets, Florida A&M University-Florida State University, Tallahassee, FL, 32311, United States, mdlbnets@gmail.com, Olumide Abioye, Masoud Kavoosi, Junayed Pasha, Eren Erman Ozguven, Ren Moses, Walter Boot, Thobias Sando

Many U.S. coastal areas, which are characterized with a significant presence of vulnerable populations (e.g.., aging adults), often experience natural hazards. In order to facilitate emergency evacuation planning, this study proposes a set of multi-objective heuristic algorithms for assigning evacuees to the available evacuation routes and emergency shelters, considering socio-demographic characteristics of evacuees, which may further affect their driving ability. Numerical experiments are conducted to evaluate the proposed solution algorithms using real life emergency evacuation scenarios.

■ MB02

CC- Room 202

Machine learning under uncertainty

Sponsored: Data Mining

Sponsored Session

Chair: Petros Xanthopoulos

1 - AUC Maximization for Binary Classification Using Combinatorial Benders Cuts

Edhem Sakarya, Ozyegin University, Istanbul, Turkey, edhem.sakarya@ozu.edu.tr, Erhun Kundakcioglu

The purpose of this study is to maximize the area under Receiver Operating Characteristic curve for binary classification using a scoring-based mixed integer linear programming formulation. We investigate exact approaches using a reformulation, combinatorial Benders cuts, and heuristic bounding methods. Our study presents computational results on benchmark data sets and paves the way for future studies on scoring-based approaches.

2 - A Risk Based Approach for Minimum Variance Ensemble Learning Algorithms

Petros Xanthopoulos, Assistant Professor, Stetson University, DeLand, FL, 32723, United States, pxanthopoulos@stetson.edu, Ramazan Unlu

In unsupervised learning local optimality of algorithms cause significant performance variability for multiple runs on a given dataset. In this paper we demonstrate a method for controlling this variability by employing optimal portfolio theory. We also discuss the tradeoff between variance and performance.

3 - Uncertainty-aware Neural Networks for Medical Image Analysis

Seonho Park, University of Florida, Gainesville, FL, United States, seonhopark@ufl.edu, Panayote (Panos) M. Pardalos

Deep learning has attracted a lot of attention in various fields of engineering because of its accuracy surpassing human level. Most of the deep learning generates deterministic predictions which might be harmful especially in the critical systems such as physician diagnosis of disease, and autonomous vehicles system. To tackle this problem, we revisit the Bayesian or non-Bayesian approaches to obtain practical uncertainty estimates in deep learning. Especially, we present approaches to give uncertainty measures to applications in medical image analytics.

4 - Pattern-based Classification with Uncertainty

Ruilin Ouyang, Northeastern University, Boston, MA, United States, ouyang.ru@husky.neu.edu, Chun-An Chou

Logical analysis of data (LAD) is a data analysis methodology for classification based on combinatorial patterns of binary data. Pattern generation is a building block in LAD and highly impacts the classification performance. However, data are usually in a numerical format with uncertainty in most real-life classification problems, e.g., medical diagnosis and fault classification in manufacturing process. In this study, we propose a robust chance-constrained programming model for pattern generation and also develop an efficient solution approach based on model reformulation.

5 - Graph-based Clustering Analysis of Semantic Spaces

Vladimir Boginski, Associate Professor, University of Central Florida, Orlando, FL, United States, Vladimir.Boginski@ucf.edu

We present our recent results on graph-based exploration and clustering analysis of semantic spaces.

■ MB03

CC- Room 203

Large-scale Statistical Inference for Contemporary Business Applications

Sponsored: Data Mining

Sponsored Session

Chair: Gourab Mukherjee

1 - Large-scale Joint Modeling of Player Attributes in Freemium Mobile Games

Gourab Mukherjee, University of Southern California, Marshall School of Business, University of So, Los Angeles, CA, 90089-0809, United States

We develop a Constrained Extremely Zero Inflated Joint (CEZIJ) modeling framework for simultaneously analyzing player activity, engagement and drop-outs (churns) in app-based mobile freemium games. Our proposed framework addresses the complex interdependencies between a player's decision to use a freemium product, the extent of her direct and indirect engagement with the product and her decision to permanently drop its usage. CEZIJ extends the existing class of joint models for longitudinal and survival data in several ways.

2 - Changing the Power Equation: A Structural Analysis of the Impact of Used Cars on the Automobile Distribution Channel

Sivaramakrishnan Siddarth, University of Southern California, Marshall School of Business, Los Angeles, CA, 90089-1424, United States, siddarth@marshall.usc.edu, Dinakar Jayarajan, Jorge Mario Silva-Risso

Most new car dealers also sell used cars from the same physical location. We formulate a structural model of the demand and supply of new and used cars and estimate its parameters using transaction data from the mid-sized sedan segment to gain insights into the nature of competition between new and used markets. On the demand side, we find that new car prices have a higher impact on used car sales than vice versa. On the supply side we compare channel profits when dealers price new and used cars jointly to those realized when pricing decisions are independent. We find that the ability to sell used cars enables new car dealers to gain more power in the distribution channel relative to manufacturers.

3 - The Effect of Demonetization on Digital Payments in India: Causal Inference in the Absence of Controls

Bikram Karmakar, PhD, University of Florida, Gainesville, Gainesville, FL, United States, Bhuvanesh Pareek, Dylan S. Small, Pulak Ghosh

On 8 Nov, 2016, the Government of India declared that two high denominations of the Indian Rupee would cease to be legal tender after midnight; 86% of the money in circulation was deemed illegal tender, resulting in a currency squeeze. We aim to assess the impact of demonetization on digitization. Specifically, we ask whether demonetization had a causal effect that led to adoption of digital payment methods and a surge in digital transactions across the country. In a quasi-experiment, we look for the differential effect of demonetization on the more affected group over the less affected. We analyze a unique retail data of more than 30 mil transactions made in a supermarket chain across three cities of India.

4 - Lease for Less: A Price Discrimination Model of Why Auto Manufacturers Subsidize Leases

Srabana Dasgupta, Simon Fraser University, Vancouver, BC, V5A 1S6, Canada, Sivaramakrishnan Siddarth, Srabana Dasgupta

Firms often offer multiple price/quality combinations of their products with the objective of segmenting the marketing between high and low valuation consumers. In the automobile industry, manufacturers can create such low- and high-quality variants of the same physical vehicle through financial instruments such as leasing and financing. To test our theory, we develop and estimate, using vehicle transaction data, a demand model that uses the distribution of mileage in the population to derive the share of leases relative to purchases for an individual brand and then incorporate this into a profit maximizing model of firm behavior to explain the price differential between leases and purchases.

■ MB04

CC- Room 204

Recent Developments of Statistical and Machine Learning Models with Business Applications

Sponsored: Data Mining

Sponsored Session

Chair: Wenbo Wu

1 - Prediction with Spatially Correlated Functional Covariates

Yeonjoo Park, University of Texas at San Antonio, San Antonio, TX, United States, yeonjoo.park@utsa.edu

We present a novel spatial model that predicts scalar responses based on functional predictors observed at spatial locations. We incorporate spatial information in modeling via three steps: dimension reduction by introducing low-rank latent variables, conducting spatial model selection, and fitting a Spatially Varying Coefficient Model (SVCM) which allows for varying impact of variables on responses over locations. To preserve spatial continuity among functional covariates on dimension reduction, we place a spatial dependent structure on estimated functional PC scores. Then model estimation and selection will be simultaneously performed through a Bayesian approach with spatial prior.

2 - Robust Estimation of Customer Churn under Competing Risks

Arkajyoti Roy, University of Texas at San Antonio, San Antonio, TX, United States, arkajyoti.roy@utsa.edu, Pallav Routh, Jeff Meyer

Uncertainties in the process of customer churn, such as competing risks and random customer behavior, can degrade churn predictions and limit the efficacy of churn management programs. We propose a competing-risk random survival forest for modeling risk of churn, which improves accuracy by 28% compared to conventional models. Furthermore, we identify relationships between risk of churn and customer behavior without relying on specific functional forms or underlying distributions.

3 - Model Confidence Bounds for Model Selection

Yichen Qin, University of Cincinnati, Cincinnati, OH, United States

We introduce the concept of model confidence bounds (MCB) for model selection in the context of nested models. MCB identifies two nested models (upper and lower confidence bound models) containing the true model at a given level of confidence. MCB proposes a group of nested models as candidates and the MCB's width and composition enable the practitioner to assess the overall model selection uncertainty. A new graphical tool —- the model uncertainty curve —- is introduced to visualize the variability of model selection and to compare different model selection procedures. Our Monte Carlo simulations and real data examples confirm the validity and illustrate the advantages of the proposed method.

4 - Sufficient Variable Screening via an Independence Index

Qingcong Yuan, Miami University, Oxford, OH, United States, qingcong.yuan@miamioh.edu

Variable screening is very popular in modern data analysis and is particular useful for large p small n data. In this paper, we propose a novel two-stage sufficient variable screening procedure, especially when the response is categorical. This procedure is very general and model-free, thus is robust against model mis-specification. In addition, our procedure always improves existing screening approach in literature which only uses marginal relation. Numerical studies are provided to demonstrate the advantages of the method.

■ MB05

CC- Room 205

Obtaining Benefits and Avoiding Pitfalls When Implementing Data Mining in Your Firm.

Sponsored: Data Mining

Sponsored Session

Chair: Vladimir Kovtun

Co-Chair: Ian Mouzon

1 - Aggregating Demand Streams Efficiently While Minimizing Increase in Forecasting Error

Vladimir Kovtun, Yeshiva University Sy Syms School of Business, New York, NY, 11375, United States, kovtunv@gmail.com, Avi H. Giloni, Sridhar Seshadri

Often firms will aggregate demand across many possible demand streams and generate one (or several) demand forecast. This is usually done based on some unifying customer characteristic(s). We propose several algorithms for clustering demand streams based on the similarity of the ARMA models which govern them. In one such approach, streams are moved from one cluster to another if certain optimization criteria are met. Another algorithm determines an objective function and utilizes a constrained non-linear minimization technique to find the best clustering assignment. These algorithms lead to (or near) a global optimum with the best forecast accuracy among all possible clustering assignments.

2 - Interpretable Prediction with Text

Yuan Cheng, Cornell University, Ithaca, NY, 14850, United States, yc956@cornell.edu, Shawn Mankad

Analyzing text for business applications requires interpretable summaries in addition to prediction accuracy. We propose a new constrained matrix factorization model, which balances maximizing statistical and predictive power of regression models with capturing the underlying textual themes. We validate the effectiveness of our proposed model in terms of the combined goal with a comprehensive benchmarking study with online reviews.

3 - Counterfactual Explanations for Data-driven System Decisions

Carlos Fernandez, Stern School of Business, NYU, New York, NY, United States, cfernand@stern.nyu.edu, Foster Provost, Xintian Han

This paper proposes to explain system decisions by defining an explanation as a set of inputs that is causal (meaning that removing them changes the decision) and irreducible (meaning that removing any subset of the inputs in the explanation does not change the decision). Our explanations are designed to explain system decisions rather than model predictions and can incorporate inputs with arbitrary data structures. We also show how model-agnostic algorithms can be tweaked to find the most useful explanations depending on the context. Finally, we showcase our approach using real data to illustrate its advantages over other methods when the goal is to understand system decisions better.

4 - “Data Nuggets” Tools for Clustering Big Data

Javier Cabrera, Rutgers University, Newark, NJ, United States

Standard clustering algorithms require pairwise distance calculation which limit the number of observations to around 100K in a basic computer, which is too small when confronted with huge datasets found in modern business applications. Possible solutions to this are to use a random sample or (more recently) to generate a set of “support vectors”. These may not be adequate however since the structure of the dataset is not guaranteed to be captured very well. We present a new solution through the concept of “data nuggets”. These will reduce a very large dataset into a small collection of nuggets of data, each containing a center, weight, and a scale parameter. With these we may apply algorithms that compute standard unsupervised and supervised statistical methods, such as clustering.

■ MB06

CC- Room 209

Predictive Analytics in Healthcare

Sponsored: Data Mining

Sponsored Session

Chair: Afrin Kahkashan

1 - Heterogeneous Recurrence Quantification Analysis for Images – in Healthcare Application

Cheng-Bang Chen, The Pennsylvania State University, State College, PA, 16801, United States, czc184@psu.edu, Hui Yang, Soundar Kumara

The recurrence dynamics of image textures provide rich information of the corresponding objects. To characterize the recurrence features of the image data, we propose a novel approach utilizing the network presentation and fractal representation to quantify the heterogeneous recurrences of the image data. Experimental results illustrate that the proposed approach yields superior performance in the extraction of salient features to distinguish different characters of a system.

2 - Nested Gaussian Process Modeling and Imputation of High Dimensional Incomplete Data under Uncertainty

Farhad Imani, The Pennsylvania State University, State College, PA, 16802, United States, Changqing Cheng, Ruimin Chen, Hui Yang

Missing values exist pervasively for intensive care unit (ICU) variables pertinent to a patient’s health condition. This adversely affects time-critical decision making in patient care. This paper presents a novel nested Gaussian process (NGP) model that is tailored to represent multi-dimensional covariance structure of time, variable and patient for high-dimensional data imputation. We evaluate and validate the proposed NGP method on real tensor-form ICU data with high-level missing information. Experimental results show that the proposed methodology handles the data uncertainty in ICU settings, which helps further improve biomarker extraction, patient monitoring and decision making.

3 - Advanced Survival Analysis for Mortality Prediction of High Dimensional Multi-view Datasets

Kahkashan Afrin, Texas A&M University, College Station, TX, 77840, United States, afrin@tamu.edu, Satish Bukkapatnam

Critical applications such as life expectancy prediction rely on the accuracies of survival models. However, these accuracies are compromised by model and data limitations such as proportional hazard assumption and the curse of imbalance and dimensionality. To address these limitations, we propose a survival analysis model using a Bayesian framework with shrinking and diffusing prior for addressing high dimensionality and selective balancing techniques for addressing the extreme imbalance in the survival datasets. Investigations using genomic and mortality dataset suggest that the proposed model provides improved performance over the traditional proportional hazards model.

4 - Effects of Outliers and Robust Logistic Regression Tree

Doowon Choi, Texas A&M University, College station, TX, United States, Li Zeng

This study investigates effects of outliers in logistic regression tree (LRT) modeling of binary outcome data in healthcare applications and develops a robust logistic regression tree (RLRT) approach that can alleviate those effects. The effectiveness and advantages of the proposed method is demonstrated in a case study using dataset on cardiac surgeries.

5 - Estimate the Complexity of Multichannel EEG Signals Using Multivariate Multiscale Entropy

Shaodi Qian, Northeastern University, Boston, MA, United States, qian.shao@husky.neu.edu, Miaolin Fan

Understanding the complexity of physical and physiological time series are important for investigating into the signal generating mechanisms. The multivariate multiscale entropy (MMSE) provides a tool for estimating the long-term regularity of multichannel signals over various time scales. In this study, we aim to explore the capability of MMSE as a quantitative method to characterize the nonlinear dynamics of human scalp electroencephalography (EEG). Two datasets were used for testing our model via discriminating patients with neurological disorders from healthy controls using the MMSE features.

■ MB07

CC- Room 210

Panel: Combatting the Epidemic: Opioid Data Integration & Mining II

Sponsored: Data Mining

Sponsored Session

Chair: Matthew Hudnall

1 - Evaluating Interventions for Opioid Abuse in Rural underserved Populations

Lesley Clack, Assistant Professor, University of Georgia, Athens, GA, 30607, United States, lesley.clack@uga.edu

While many potential interventions for treating substance abuse exist, their efficacy can vary greatly across locations, populations, and types of addictions. Research on the efficacy of predicting intervention strategies in rural/underserved opioid populations is limited. The goal of this research study was to explore and rigorously define the spectrum of available intervention strategies for opioid abusers in rural/underserved communities in order to be able to evaluate the potential effectiveness of each intervention strategy using statistical tools and relevant empirical evidence.

2 - Medical Claims Data Mining in the Early Stages of Opioid Use

Katherine Bobroske, University of Cambridge, Trumpington Street, Cambridge, CB2 1AG, United Kingdom, kab80@jbs.cam.ac.uk

Medical and pharmaceutical claims provide a rich basis for studying how healthcare delivery design impacts a patient's opioid use. We integrated the claims sets of a US company (that hosts data for approximately 3.5 million patients) to infer the medical context of the patient's opioid use journey. Our research focuses on two key areas related to early-stage opioid use: (1) the impact of utilizing opioids as first-line therapy in preference-sensitive conditions and (2) whether continuity of care (typically promoted for managing chronic opioid patients) or a second opinion (by a clinician other than the original opioid prescriber) is more effective in curbing long-term dependence.

3 - Panelist

Ebrahim Mortaz, Pace University, New York, NY, 10038, United States, emortaz@pace.edu, Ali Dag

Drug overdose is the leading cause of accidental death in the United States, and opioid addiction drives this epidemic. In this talk, we propose a data analytics framework that aims to offer the best possible prediction for the opioid prescription for post-op orthopedics procedures. The proposed framework includes machine learning algorithms accompanied by feature selection efforts based on genetic algorithm and particle swarm optimization.

4 - Panelist

Hossein Najmi, University of North Texas, Denton, TX, 76201, United States

■ MB08

CC- Room 211

Recent Developments in Optimization for Machine Learning

Emerging Topic: Artificial Intelligence & Machine Learning

Emerging Topic Session

Chair: Raghu Bollapragada, Northwestern University, Evanston, IL, 60201, United States

1 - Recent Results in Sub-sampled Second Order Optimization Methods

Michael W. Mahoney, University of California-Berkeley, Berkeley, CA, United States

Sub-sampling has proven to provide a way to develop scalable optimization algorithms for many machine learning problems. Most work has focused on first order algorithms, e.g., stochastic gradient descent, but recent work has focused on sub-sampled Newton-type methods. We will describe the motivation, several recent theoretical results, and how the theory is used in several machine learning applications.

2 - Adagrad Stepsizes: Sharp Convergence over Nonconvex Landscapes

Xiaoxia (Shirley) Wu, University of Texas at Austin, Austin, TX, United States, xwu@math.utexas.edu

Adaptive gradient methods (AdaGrad) have gained widespread use in large-scale optimization for their ability to converge without the need to fine-tune parameters. Yet, the theoretical guarantees to date for AdaGrad are for convex optimization. We bridge this gap by providing strong theoretical guarantees for the convergence of AdaGrad over smooth, nonconvex landscapes. We show that the norm version of AdaGrad (AdaGrad-Norm) converges at the $O(\log(N)/\sqrt{N})$ rate in the stochastic setting and at the $O(1/N)$ rate in the batch setting. Both our theoretical and numerical results imply that AdaGrad-Norm is robust to the unknown Lipschitz constant and level of stochastic noise on the gradient.

3 - Quasi-newton Methods for Deep Learning: Forget the Past, Just Sample

Albert Solomon Berahas, Lehigh, Bethlehem, PA, 18018, United States, albertberahas@lehigh.edu, Majid Jahani, Martin Takac

In this talk, we present two sampled quasi-Newton methods for deep learning: sampled LBFGS and LSR1. Contrary to the classical variants of these methods that sequentially build Hessian approximations as the optimization progresses, our proposed methods sample points randomly around the current iterate at every iteration to produce these approximations. As a result, the approximations constructed make use of more reliable (recent and local) information. We provide convergence guarantees for the methods, discuss possible large-scale parallel/distributed implementations and illustrate their performance on several neural network training task.

4 - Towards understanding Embeddings and Optimization for Deep Neural Recommendation Systems

Hao-Jun M. Shi, Northwestern University, Evanston, IL, United States, hjmshi@u.northwestern.edu

Modern recommendation systems exploit categorical features by representing each feature by an embedding vector prior to passing this through a neural network architecture. Notably, these embeddings are simultaneously trained with the network parameters. The presence of these large embedding tables yields high-dimensional optimization problems (in the order of tens of billions), sparsity of the activations and gradients, and a mysterious phenomenon when training over multiple epochs. I will present my recent work on reducing the dimension of these models, understanding the multi-pass training phenomena, and devising specialized algorithms for training recommendation models.

■ MB09

CC- Room 212

Deep Learning and Neural Networks

Sponsored: Artificial Intelligence

Sponsored Session

Chair: Maria Calisto

Co-Chair: Susana Lai-Yuen, University of South Florida, Tampa, FL, 33620, United States

1 - Adapting an Ensemble of Fully Convolutional Networks with Multiobjective Evolutionary Optimization

Maria Baldeon Calisto, University of South Florida, Tampa, FL, 33647, United States, mariabaldeon@mail.usf.edu, Susana Lai-Yuen

Deep learning methods have become very successful at solving complex tasks. However, given the vast number of hyperparameters and massive search space, finding the proper configuration for a problem requires extensive experience and time. In this work, we propose an ensemble of Fully Convolutional Networks (FCNs) that adapts to a particular 3D image dataset through a multiobjective evolutionary-based algorithm, which minimizes both the model s error and size. The ensemble is comprised of a 2D FCN that extracts intra-slice information, and a 3D FCN that exploits inter-slice information. The model is evaluated on the complex problem of 3D medical image segmentation.

2 - Neural Networks for Prediction of HIV Incidence in Compartmental Modeling

Hanisha Tatapudi, University of South Florida, Tampa, FL, 33647, United States, tatapudi@mail.usf.edu, Seyedeh Nazanin Khatami, Chaitra Gopalappa

The annual number of new HIV infections is a key metric of decision-analytic models for evaluating HIV control strategies. Agent-based models (ABM) and compartmental models are commonly used simulation tools for such analysis, however, they're computationally inefficient and fail to capture non-linear dynamics of contact structures, respectively. We test the fidelity of training a neural network (NN) for prediction of new infections, using ABM samples, to replace the regression model in compartmental models. This hybrid model is key to analyzing 'how to reach zero new HIV infections in the US?'. We use dropout, a regularization method, to transform the deterministic NN to a stochastic model.

3 - Deep Learning Based Technique for Imaging Biomarker Identification Using 3D Kidney MRI

Yanzhe "Josh" Xu, Arizona State University, Tempe, AZ, United States, yanzhexu@asu.edu, Teresa Wu, Fei Gao, Jennifer Charlton, Kevin Bennett

Imaging biomarkers are being rapidly developed for early diagnosis and staging of disease. Detecting and segmenting objects from images are often the first steps in quantitative measurement of these biomarkers. The challenges of detecting objects in images, particularly small objects known as blobs, include low image resolution, image noise and overlap between the blobs. In this research, we propose a deep learning based technique, UH-DoG, to overcome these problems. Improved performance is obtained compared with other methods.

4 - Deep Reinforcement Learning Based Adversarial Evaluation of a Cyber Alert Management System

Ankit Shah, University of South Florida, Tampa, FL, United States

Timely analysis of cyber alerts is the primary goal of a cybersecurity operations center (CSOC). If the alerts remain unanalyzed for a long duration, malicious activities will persist in a network and cause serious damage. Recently, a reinforcement learning (RL) based defender system was proposed for near-optimal alert management at a CSOC in the wake of stochastic events. In this talk, we evaluate the defender's policy of actions by developing a deep RL based strategic adversary. The goal of the adversary is to learn the best policy of actions by interacting with the defender. Results show that by utilizing the concepts of experience replay and target network, adversary is able to outsmart the defender.

5 - Anomaly Detection in Deep Spatio-temporal Metamodeling for Cardiac Electrical Conduction Simulation

Xinyu Zhao, Arizona State University, Tempe, AZ, United States, xzhao119@asu.edu, Hao Yan, Zhiyong Hu, Dongping Du

Modeling and simulation have been widely used in both cardiac research and clinical study to investigate cardiac disease mechanism and develop new treatment design. However, the complexity of existing model makes the simulation time-consuming. This paper develops a new spatiotemporal model as a surrogate model of the time-consuming cardiac model. Specifically, we propose to investigate the auto-regressive convolutional neural network and convolutional long short-term memory to model the spatial and temporal structure for the metamodeling. The metamodel can accurately capture the properties of the individual cardiac cell, as well as the electrical wave morphology in cardiac fiber.

■ MB10

CC- Room 213

2019 SMA Best Student Paper Award

Sponsored: Social Media Analytics

Sponsored Session

Chair: Julie Zhang, University of Massachusetts-Lowell, Lowell, MA, 01854, United States

1 - SMA Best Student Paper Award

Theodore T. Allen, Ohio State University, Columbus, OH, 43210-1271, United States, allen.515@osu.edu

The Social Media Analytics Section of INFORMS announces the 2019 Best Student Paper Award to recognize excellence among its student members. Four finalists for the Best Student Paper Award will be selected to make presentations at the INFORMS Annual Meeting in Seattle, Washington. The winner will be announced at the Social Media Analytics business meeting later at the conference.

2 - Sympathy to the Seemingly Needy: Does Social Influence Alleviate Inequalities in Medical Crowdfunding?

Yun Young Hur, Georgia Institute of Technology, Atlanta, GA, 30312, United States, Fujie Jin

One major challenge in medical crowdfunding is the unequal chances of funding success. Cases with certain attributes that seem to be in greater need of help are usually more likely to receive donations. In this study, we first demonstrate the existence of donation inequalities. We present a potential explanation for such unequal chances based on the signaling theory and further propose that social influence potentially reduces donation inequality, by providing an additional signal of validity and funneling attention to cases that are likely overlooked otherwise. We conduct a large-scale randomized field experiment with a leading medical crowdfunding platform to examine whether leveraging social influence, through displaying friends' donation information, influences users' willingness to donate and how the impact differs for cases involving male and female patients. Our results show that social influence alleviates gender inequality in donations, particularly for cases lacking other strong signals such as involving patients of young age or with cancer-related conditions. On the other hand, presence of other strong case-level signals makes patient gender a redundant signal and therefore, social influence's impact on willingness to donate is likely similar across patient gender in these cases. Our findings on how social influence mitigates donation inequalities yield significant policy implications in promoting equality in medical crowdfunding.

3 - Does Social Media Speed Up Product Recalls? Evidence from Pharmaceutical Industry

Yang Gao, University of Rochester, Rochester, NY, United States, Huaxia Rui, Wenjing Duan

Social media becomes a vital platform to voice experiences or concerns related to products. Those voices not only provide signals of potential defects but also impose pressures on firms. Few systematic works have examined the influence of those voices from social media on product recalls. This study scrutinizes the relationship by focusing on the pharmaceutical industry since social media pharmacovigilance is becoming increasingly crucial for detecting drug safety signals. Using drug enforcement reports provided by FDA and social media data crawled from online forums and Twitter, we investigate whether social media can speed up drug recalls. The results derived from the discrete-time survival analysis suggest that more mentions on social media would lead to a higher hazard rate of being recalled and thus shorter time to recall. To better understand the underlying mechanism, we propose two effects: information and publicity effects and validate their impact with additional analyses. Collectively, this study proffers new insights for both managers and policymakers concerning the power of social media and its influence on product recalls.

4 - Detecting Customer Trends for Optimal Promotion Targeting

Tamar Cohen, Massachusetts Institute of Technology, Cambridge, MA, 02144, United States, Georgia Perakis

Trends can help retailers determine promotion plans. Social media data is essential for understanding these trends, but it is often unavailable. We introduce a demand model that captures these social interactions from transaction data. The resolting promotion targeting problem is NP-hard to solve, so we develop a greedy approach.

5 - The Effect of User Generated Content on Hotel Demand: The Role of Competitive Perception Spillovers

Sanghoon Cho, University of South Carolina, Columbia, SC, 29206, United States, Wang Jain, Pelin Pekgun, Ramkumar Janakiraman

We study the impact of user generated content (UGC) on hotel performance as measured by actual hotel bookings with a focus on the spillover effects from a focal hotel's competitors' UGC on its demand. Drawing on prospect theory, we cast the competitive perception spillovers of UGC as \gains" and \losses" in user reviews of the focal hotel, relative to its competitors. We propose a Bayesian learning model of consumers' dynamic updating of their perceptions of a hotel over time based on prior perceptions and new information in the form of UGC. To test our proposed model, we leverage a unique data set that has actual bookings of two hotel properties (of a major hotel chain) in two different markets in the United States. We supplement our unique data set with UGC garnered from a popular social media platform, TripAdvisor. We found that review sentiment, relative to competition, has a significant effect on a hotel's booking performance and that the relative negative sentiment (losses) has a higher influence on bookings than relative positive sentiment (gains). Specifically, we found that an increase in a hotel's positive (negative) sentiment score by one point, relative to competition, leads to 2.7% increase (4.5% decrease) in its bookings. To the best of our knowledge, our study is the first to quantify the effect of valence of UGC on hotel bookings. We propose and found evidence of the moderating effect of a hotel's own prices on competitive spillover effects. We also document sensitivities to price and UGC across different hotel customer segments. Our results provide hoteliers with new insights on how to leverage UGC for improved revenue management.

6 - A Twitter-Based Cyber Security Warning and Prioritization System

Enhao Liu, Ohio State University, Columbus, OH, 43210, United States, Theodore T. Allen

Cyber vulnerability management is difficult because there are more than 16,000 distinct vulnerabilities distributed across large numbers of hosts including PCs, laptops, printers, or even die casting or exercise machines. Fortunately, at any given time, only a tiny fraction of vulnerabilities are actually causing incidents. Further, by combining modeling, local data about vulnerabilities and incidents, and Twitter data, we demonstrate that warnings about specific vulnerabilities can likely provide enough specific intelligence to eliminate perhaps the majority of incidents. We use data from a Midwest university to demonstrate the system. The derived model predicting the probability an exploit exists for a Tweeted vulnerability, an indication of risk priority, has an AUC of 0.904 and the time series model to predict incident counts has all coefficients with p-values less than 0.05.

■ MB11

CC- Room 214

Joint Session APS-HAS: Special Invited Lecture on Healthcare Operations

Sponsored: Applied Probability

Sponsored Session

Chair: Jing Dong, Columbia University, New York, NY, 60208, United States

Co-Chair: Jamol Pender, Cornell University, Ithaca, NY, 14850, United States

1 - Applied Probability for Healthcare Management: Nurse Staffing Models

Carri Chan, Columbia Business School, 3022 Broadway, Uris Hall, New York, NY, 10027, United States, cwchan@columbia.edu

Applied probability approaches have been useful in shedding insights into the management of healthcare systems. These systems often introduce unique features which make direct translation of prior results in other service systems challenging. This tutorial will review models and approaches which capture important aspects of healthcare systems and have been used to understand the impact of nurse staffing on patient flow and patient outcomes. I will also describe some recent work that introduces new patient management challenges and insights due to heterogeneity in staffing requirements for different patient types.

■ MB12

CC- Room 2A

Reinforcement Learning and Data-Driven Control

Sponsored: Applied Probability

Sponsored Session

Chair: Daniel Russo, Columbia University, Northwestern University, New York, NY, 60208, United States

1 - Beating the Curse of Dimensionality in High-dimensional Options Pricing and Optimal Stopping

David Goldberg, Cornell University, Ithaca, NY, 14850, United States, dag369@cornell.edu, Yilun Chen

The fundamental problems of pricing high-dimensional options and optimal stopping are generally believed to be intractable, with modern ADP, duality, and simulation approaches either scaling poorly, requiring knowledge of basis functions, or having limited guarantees. We show that this general belief is incorrect, by developing the first algorithm which allows one to elegantly trade-off between accuracy and runtime through a parameter epsilon controlling the performance guarantee (analogous to a PTAS), with computational and sample complexity both polynomial in T (effectively independent of the dimension) for any fixed epsilon, in contrast to past methods which scale exponentially.

2 - The Optimality of Sparse Model Based Planning for Markov Decision Processes

Sham Kakade, University of Washington, Seattle, WA, United States

We study optimal planning in an MDP with samples using the most natural approach: we first find an optimal policy using a "plug-in" estimated model, where we use the maximum-likelihood model estimate from observed transitions, and then we consider the optimal policy in our estimated model. We show that that is approach is non asymptotically, statistically minimax optimal (matching the lower bounds); the bound holds in the sparse regime, where the learned model has a number of nonzero entries that is sub-linear in the model size. This resolves the question of wether a sparse model based planning approach can be statistically minimax optimal.

3 - Presenter

Stephen Tu, UC Berkeley, Berkeley, CA, United States

The effectiveness of model-based vs. model-free methods is a long-standing question in reinforcement learning (RL). Motivated by recent empirical success of RL on continuous control tasks, we study the sample complexity of popular model-based and model-free algorithms on the Linear Quadratic Regulator (LQR). We show that simple model-based plugin methods outperform classical model-free algorithms by at least a factor of state and input dimension. To the best of our knowledge, this is the first theoretical result which demonstrates a separation in the sample complexity between model-based and model-free methods on a continuous control task.

4 - Newton, Polyak and Nesterov: Quickest Stochastic Approximation and Reinforcement Learning

Adithya Devraj, University of Florida, Gainesville, FL, United States, Sean Meyn

It was shown in recent work by the authors that Q-learning is slow because its variance is infinite. Three new Q-learning algorithms are introduced to dramatically improve performance: (i) The Zap Q-learning algorithm that has provably optimal asymptotic variance, and resembles the Newton-Raphson method in a deterministic setting (ii) The PolSA algorithm that is based on Polyak's momentum technique, but with a specialized matrix momentum, and (iii) The NeSA algorithm based on Nesterov's acceleration technique. Coupling techniques are used to establish convergence rates for the new algorithms.

■ MB13

CC- Room 2B

New Researchers in Applied Probability and Stochastic Systems

Sponsored: Applied Probability

Sponsored Session

Chair: Alessandro Arlotto, Duke University, Durham, NC, 27708, United States

1 - Dynamic and Stochastic Knapsack Problems with Equal Rewards

Xinchang Xie, Duke University, Durham, NC, United States, xinchang.xie@duke.edu, Alessandro Arlotto

We study a dynamic and stochastic knapsack problem with n items with equal rewards and independent weights from a known continuous distribution. A decision maker seeks to maximize the expected total reward of items that she includes in a knapsack with finite capacity by making terminal decisions as soon as each item weight is revealed. We prove that the regret—the expected gap between the performance of the best sequential algorithm and that of a prophet—is logarithmic in n. We devise a re-optimized heuristic that achieves this regret bound. We also show that the total rewards collected by our heuristic, by the best sequential algorithm, and by the prophet share the same limiting distribution.

2 - A New Approach to High-dimensional Online Decision-making

Yilun Chen, Cornell ORIE, 292 Rhodes Hall, Ithaca, NY, 14853, United States, yc2436@cornell.edu, David Goldberg

High-dimensional stochastic dynamic programs(DP) arise in many practical settings, yet are believed to be computationally intractable in general. Building on recent algorithmic progress of Chen and Goldberg for optimal stopping, we devise a new algorithm that overcomes this fundamental computational barrier for a fairly general class of stochastic DP, subject to a ``limited policy change" condition. Beyond this, our results allow for arbitrarily complex dynamics of the underlying state, assuming only access to a black-box simulator. Time permitting, we also discuss several improvements to the original approach of Chen and Goldberg for optimal stopping.

3 - Dynamical Scheduling in Clearing Systems: Asymptotic Optimality of a Strict Priority Policy under Fluid Scaling

Lun Yu, Northwestern University, Evanston, IL, 60208, United States, Seyed Iravani, Ohad Perry

We consider a finite-horizon optimal scheduling problem for a clearing queueing system with two classes of impatient customers: The system starts with a significant backlog at time 0, which it needs to clear, while new demand, that matches the system's capacity, keeps arriving. The goal is to find an optimal scheduling policy that minimizes a linear holding-and-abandonment cost, up to the time when the queue is cleared. Based on a fluid approximation, we prove that a static priority policy is asymptotically optimal under different limiting regimes; analyze the impacts of preemption; and generalize the results to systems with multiple customer classes.

4 - Queues Networks Control with Primal Dual Reinforcement Learning

Yi Chen, Northwestern University, Evanston, IL, United States, yichen2016@u.northwestern.edu, Jing Dong, Zhaoran Wang

Queueing networks control is widely used in many fields, such as healthcare, ridesharing. There are numerous literatures on this problem. However, most of previous works are model-based and do not work well when the networks are complicated. In this work, we try to use reinforcement learning techniques, to solve this problem, which is model-free.

■ MB14

CC- Room 302

Counterfeit and Fake Purchase Problems

Sponsored: Manufacturing & Service Oper Mgmt

Sponsored Session

Chair: Li Chen, Cornell University, Ithaca, NY, 14853, United States

1 - Luxury Pricing with Status-seeking Consumers and Strategic Counterfeiters

Zhen Lian, Cornell Tech, New York, NY, 10018-6280, United States, zl458@cornell.edu, Li Chen

We study the effects of non-deceptive counterfeits in the luxury market when consumers are status seeking. Without counterfeits, the status effect elevates consumers' demand and increases luxury brands' optimal prices and revenue. With counterfeits, we show that the status effect can be completely negated.

2 - Luxury Brands and Online Marketplace: Friend or Foe?

Yini Gao, Singapore Management University, 50 Stamford Road, #04-10, Lee Kong Chain School of Business #4031, Singapore, 178899, Singapore, yngao@smu.edu.sg, Wei Shi Lim, Ziqiu Ye

The expansion of the online marketplace has led to firms leveraging on it to increase access to consumers. However, the online marketplace is also a main propagator of the counterfeits. To study the dilemma faced by luxury brands, we adopt a game-theoretic framework to examine the interactions among a luxury brand seller, a counterfeit seller, and an online marketplace. We find that the online marketplace never deters the counterfeit seller. An authentic luxury brand seller may sell on the counterfeit prevalent marketplace when it has a low production cost but a high direct channel operating cost. The counterfeit the firm can discourage the authentic firm's entry with a high-quality counterfeit.

3 - Blockchain Adoption for Combating Deceptive Counterfeits

Hubert Pun, The University of Western Ontario, London, ON, N6A 3K7, Canada, hpun@ivey.ca, Jayashankar M. Swaminathan, Pengwen Hou

We consider a market with a manufacturer and a deceptive counterfeiter. The manufacturer can either use blockchain or signal through pricing to validate product authenticity. The government can incentivize blockchain adoption by providing subsidy to the manufacturer while optimizing social welfare. We find that without government subsidy, blockchain should be used only when the counterfeit quality is intermediate or when customers have intermediate distrust about products in the market. With subsidy, differential pricing strategy should never be used. Blockchain can be more effective than differential pricing strategy in eliminating post-purchase regret.

4 - Seeding the Herd: Pricing and Welfare Effects of Social Learning Manipulation

Yiangos Papanastasiou, University of California-Berkeley, Haas School of Business, Berkeley, CA, 94720, United States, yiangos@haas.berkeley.edu, Li Chen

This paper investigates the pricing and welfare effects of social learning manipulation within the classic model of binary observational learning.

■ MB15

CC- Room 303

Responsible Research in Operations Management

Sponsored: Manufacturing & Service Oper Mgmt

Sponsored Session

Chair: Serguei Netessine, The Wharton School, Philadelphia, PA, 19104, United States

1 - Serving Democracy: Evidence for Voting Resource Disparity in Florida

Dawson Kaaua, University of Pennsylvania, 3730 Walnut Street, Suite 500, Philadelphia, PA, 19104, United States, kaaua@wharton.upenn.edu, Gerard P. Cachon

We conduct the first panel data study examining whether minority and Democrat voters in Florida experience lower poll worker staffing, which could lengthen the time to vote. We do not find evidence of a disparity directly due to race, but we do observe a political party effect - a 1% increase in the percentage of Democrat registered voters in a county increases the number of registered voters per poll worker by 2.8%. This effect appears to be meaningful - using a voting queue simulation, a 5% increase in voters registered as Democrat in a county could increase the average wait time to vote from 40 minutes (the estimated average wait time to vote in Florida in 2012) to about 100 minutes.

2 - Agricultural Productivity and the Environment: Is Big Ag Evil?

Canberk Ucel, Doctoral Candidate, The Wharton School, Jon M. Huntsman Hall Room 527.5, Philadelphia, PA, 19104, United States, ucel@wharton.upenn.edu, Marshall L. Fisher, John Paul MacDuffie

U.S. agriculture has demonstrated outstanding productivity growth in the past half-century. These productivity gains came with sweeping technological and organizational changes. The public is increasingly concerned about the negative environmental and health effects of this unfamiliar mode of agriculture. Driven by extensive contextual information on the industry and with a unique focus on farm-level decisions, I first hypothesize about how organizational and production practices at the farms contribute to economic and environmental outcomes. Then, I use data from various public and private sources to quantitively investigate these hypotheses.

3 - Field Experiments with Rechargeable Lights in Rwanda

Bhavani Shanker Uppari, Singapore Management University, Singapore, 178899, Singapore, Serguei Netessine, Ioana Popescu, Rowan Clarke, Manuel Barron, Martine Visser

A significant proportion of world's population does not have access to electricity. Solar-based solutions are usually unaffordable due to consumers' poverty. There are alternative business models relying on rechargeable light bulbs that are sold at a subsidized price and require regular payments for recharges. We investigate the viability of these recharge-based models under poverty. In collaboration with a firm in Rwanda, we collected the bulb usage data from randomized experiments wherein the price and the bulb capacity were varied. We also build a structural model that incorporates the light consumption dynamics, and use it to evaluate theoretically-preferred changes to the existing model.

4 - Setting Retail Staffing Levels: A Methodology Validated with Implementation

Santiago Gallino, University of Pennsylvania, Jon M. Huntsman Hall, Philadelphia, PA, 19104, United States, Marshall L. Fisher, Serguei Netessine

Neither retail practice nor the academic literature provides a method for setting store associate staffing at the individual store level. We present and validate a systematic approach to do that.

■ MB16

CC- Room 304

MSOM Fellows Speech

Sponsored: Manufacturing & Service Oper Mgmt

Sponsored Session

Chair: Gad Allon, University of Pennsylvania, Philadelphia, PA, 19104, United States

Co-Chair: Wedad Jasmine Elmaghraby, University of Maryland, RH Smith School of Business, College Park, MD, 20742-1815, United States

1 - "Theompirical" (Theoretical + Empirical) Research of Service Systems (Hospitals, Call Centers, Banks, Courts), in Support of Their Science, Engineering and Management

Avishai Mandelbaum, Technion - Israel Institute of Technology, Haifa, Israel

I shall describe my personal research journey through service systems (e.g. hospitals, telephone and chat centers, banks, courts,). I view these systems through MS/IE/OM lenses, often more specifically as a queueing scientist (e.g. "enjoying" congestion and flows), and sometimes using operational characteristics as surrogates for financial, psychological and clinical performance. The research goal is creation of principles and tools that support the above viewpoints; and the means for achieving this goal is the marriage of theory with data. To be more concrete, I am modeling complex service systems as relatively simple (robust) processing networks. My theoretical framework is (asymptotic) queueing theory, specifically parsimonious fluid models and their diffusion refinements: queueing theory is ideally suitable for capturing the operational tradeoff that is at the core of any service, namely quality vs. efficiency (possibly augmented with fairness or profitability); and asymptotic analysis accommodates complex service characteristics that are otherwise intractable, for example transience, scale and scope. My data/empirical framework builds on an extensive data repository of service event-logs, at the level of the individual customer-server transactions (e.g. patient-physician). Marrying theory with data, as I see it, will culminate in the creation of models directly from data - automatically and in real-time - and consequently the validation of the models' value against actual service systems. (This is in contrast to prevalent OR/MS/IE/OM practice, where models are too often remote from data, and approximations are validated for merely accuracy relative to their originating models.) Specifically, data-based models - simulation, empirical, statistical and mathematical - will be created via process-mining of their primitives, structure and protocols. Simulation models will then serve as a validation ground for the other models, and all will be universally accessible for applications by researchers, students and in the longer-run practitioners. The above research agenda has been advanced, over more than a decade, at the Technion SEE Laboratory (SEE = Service Enterprise Engineering); SEELab data will hence be used, throughout my lecture, to make it concrete.

■ MB17

CC- Room 305

Markets and Equilibria II

Sponsored: Manufacturing & Service Oper. Mgmt/Service Operations

Sponsored Session

Chair: Krishnamurthy Iyer, University of Minnesota, United States, kriyer@umn.edu

1 - Auction Design for Roi-constrained Buyers

Negin Golrezaei, Massachusetts Institute of Technology, Cambridge, MA, 02142, United States, golrezae@mit.edu, Ilan Lobel, Renato Paes Leme

We combine theory and empirics to (i) show that some buyers in online advertising markets are financially constrained and (ii) demonstrate how to design auctions that take into account such financial constraints. We use data from a field experiment where reserve prices were randomized on Google's advertising exchange. We find that, contrary to the predictions of classical auction theory, a significant set of buyers lowers their bids when reserve prices go up. We show that this behavior can be explained if we assume buyers have constraints on their minimum return on investment (ROI). We then design optimal auctions for ROI-constrained buyers.

2 - Regulating Markets for Personal Information

Rachel Cummings, Georgia Tech, Atlanta, GA, 30332-0205, United States

Verifiable personal information is becoming readily available to companies for risk-based discrimination—e.g., FitBit data and GPS trackers for pricing insurance. As “low risk” individuals are incentivized to share personal data for financial gain, the decision to not share is increasingly disclosive of “high risk” attributes. To prevent unraveling, policy makers could regulate the market for personal information. In this work, we quantify the social welfare loss from market unraveling, and consider disparate effects of privacy loss on protected groups. We also study optimal design of constrained signaling schemes, taking into account privacy, fairness, and accuracy in decision-making.

3 - Coordinating Distributed Experimentation in Dynamic Markets

Ankur Mani, University of Minnesota, Minneapolis, MN, 63108-2432, United States, amani@umn.edu

We consider the problem of experimentation and learning in sharing economy platforms. There are a few features of this environment that makes it different from the traditional experimentation problems faced by monopolies. First, all participants in the platform make the decisions independently. Second, there are positive externalities associated with experimentation; the spill over of the information helps other participants. Third, the environment is dynamic and the learning becomes obsolete over time. We introduce a coordination policy and show that if the arrival/departure rate is above a certain threshold, then the firm can maintain high quality information for the participants.

4 - Dynamic Credit-collections Optimization

Naveed Chehrazi, McCombs School of Business, Austin, TX, 78712, United States, Peter Glynn, Thomas A. Weber

Based on a dynamic model of the stochastic repayment behavior exhibited by delinquent credit-card accounts in the form of a self-exciting point process, a bank can control the arrival intensity of repayments using costly account-treatment actions. A semi-analytic solution to the corresponding stochastic optimal control problem is obtained. For a linear cost of treatment effort, the optimal policy in the two-dimensional (intensity, balance)-space is described by the frontier of a convex action region. The unique optimal policy significantly reduces a bank’s loss given default and concentrates the collection effort onto the best possible actions at the best possible times.

■ MB18

CC- Room 306

People Centric Operations

Sponsored: Manufacturing & Service Oper. Mgmt/Supply Chain

Sponsored Session

Chair: Santiago Gallino, University of Pennsylvania, Philadelphia, PA, 19104, United States

1 - Fulfillment by Platform and Upstream Market Power

Jiding Zhang, The Wharton School, Philadelphia, PA, 19104, United States, jiding@wharton.upenn.edu, Amandeep Singh, Senthil Veeraraghavan

Our research shows that Fulfillment by Platform leads to a more monopolistic upstream market.

2 - Surfacing the Submerged State: Operational Transparency Increases Trust in and Engagement with Government

Ryan Buell, Harvard Business School, Boston, MA, 02163, United States, rbuell@hbs.edu, Ethan Porter, Michael Norton

As trust in government reaches historic lows, frustration with government performance approaches record highs. We propose that peoples’ perceptions of government and their levels of engagement with it can be reshaped and enhanced by increasing government’s operational transparency - that is, by designing service interactions so that citizens can see the often-hidden work that government performs. Boston residents who used an app to report service requests to their government exhibited significant increases in engagement if they were shown a photo of the work being performed. Laboratory experiments unpack the psychological mechanisms linking transparency to increased engagement.

3 - Pay by the Hour or Pay by the Task?

Santiago Gallino, University of Pennsylvania, Philadelphia, PA, 19104, United States, Carolyn Deller

We empirically study the implications of the payment contract type on productivity and quality of outcomes. We designed a set of real tasks to learn the different productivity outcomes across contracts that way in which these outcomes can be affected through additional incentives.

4 - Democracy on the Line: Polling Place Closures and Their Estimated Impact on Wait Times in the 2016 Presidential Election in Georgia

Dawson Kaaua, University of Pennsylvania, 3730 Walnut Street, Suite 500, Philadelphia, PA, 19104, United States, kaaua@wharton.upenn.edu, Gerard P. Cachon

Between the 2012 and 2016 presidential elections, Georgia closed polling places while South Carolina’s polling place count remained flat. Based on wait times reported by voters in each state during the 2006, 2008, 2012, and 2016 elections, we perform a difference-in-differences analysis with Georgia as the treatment state and South Carolina as the control to examine the impact of the polling place closures on wait times in Georgia’s 2016 election. We estimate that polling place closures increased Georgia’s average wait time by 74% or approximately 7 minutes. In addition, the increase in wait time suggests that Georgia may not have redistributed all of its voting resources from polling place closures.

■ MB19

CC- Room 307

Retail Operations

Sponsored: Manufacturing & Service Oper. Mgmt/Supply Chain

Sponsored Session

Chair: Pnina Feldman, Boston University, Boston, MA, 02215, United States

1 - The Subscription Box Business Model: Learning, Shipments and Returns

Pnina Feldman, Boston University, Questrom School of Business, Boston, MA, 02215, United States, pninaf@bu.edu, Elnaz Karimi, Ella Segev

The subscription box business model has gained popularity across firms and consumers in recent years. This model promises a periodic delivery of a box of customized consumer goods to its customers in exchange for a subscription fee. In this study, we investigate customer preference learning in the context of a firm using the subscription box business model under various contract structures.

2 - Operational Execution and Pop Display Effectiveness: Evidence F\from Adoption of an IoT Technology

Ioannis Stamatopoulos, University of Texas at Austin, McCombs School of Business, Austin, TX, 78705, United States, yannis.stamos@mccombs.utexas.edu, Ashish Agarwal, Zijian Zeng

We use the adoption of an innovative IoT technology by a large retailer chain in the US to evaluate the operational execution of promotional inventory campaigns, as well as the effectiveness of these campaigns.

3 - The Effect of Multi-Channel and Omni-Channel Retailing on Physical Stores

Fei Gao, Indiana University Bloomington, Bloomington, IN, 47405, United States, fg1@iu.edu, Shiliang Cui, Vishal Agrawal

We study how a multi-channel or omni-channel retailer should decide the number and size of physical stores. We also study the effect of three common omni-channel strategies: physical showrooms, in-store return, and in-store pick-up.

4 - Information Sharing on Retail Platforms

Fuqiang Zhang, Washington University in St. Louis, Olin Business School, St. Louis, MO, 63130, United States, Zekun Liu, Dennis Zhang

This paper studies how a retail platform should share demand information with retailers selling substitutable products on the platform. We find that the optimal strategy is to either share all information with a subset retailer or partial information with all retailers. We also propose a simple pricing mechanism that can induce the optimal sharing outcome for the platform.

■ MB20

CC- Room 308

Joint Session INFORMed/Practice Curated: Applying Analytics/OR/MS to Improve Student Outcomes

Sponsored: Education

Sponsored Session

Chair: Kingsley Anthony Reeves, University of South Florida, Tampa, FL, 33620, United States

Co-Chair: Grisselle Centeno

1 - An Optimization-based Decision Support System for Student-to-teacher Assignment

Matthew D. Bailey, Professor of Analytics and Operations Management, Bucknell University, Freeman College of Management, Taylor Hall, Lewisburg, PA, 17837, United States, matt.bailey@bucknell.edu

School administrators spend their summers attempting to assign hundreds of students to teachers for the following school year. These assignments must satisfy federal guidelines, parent preferences, and principal preferences while pursuing classroom parity and equity in regards to academic performance, behavioral support, and demographics. We formulate the problem as a mixed integer program, present the implemented spreadsheet model interface, and illustrate on a set of student data. This system is currently in use for the assignment of 600 students to 24 classrooms saving dozens of staff and administration hours.

2 - Using System Dynamics to understand the Complexities Instructional Change in Higher Education

Juan M. Cruz, Rowan University, Glasboro, NJ, United States, juancruz@vt.edu

The purpose of this study is to create a conceptual System Dynamics Model (SDM) to understand how the dynamics of the academic system affect faculty motivation to enact and sustain instructional change. The model was constructed through an iterative process of three phases: 1) a theoretical Causal Loop Diagram (CLD), 2) an empirical CLD, and 3) a conceptual SDM. The resultant 34 CLDs are classified in five categories: change management, culture, institutional support, student experience and pedagogical knowledge. Their analysis explains potential unintended consequences of decisions and policies, possible sources of resistance, and suggests potential leverage points to instructional change.

3 - Identification of Critical Moments that Prevent Four-year Graduation

Xufei Liu, University of South Florida, Tampa, FL, 33612, United States, Kingsley Anthony Reeves, Changhyun Kwon

Based on recent student course registration and grade records, we develop a model for descriptive analytics to identify critical moments that prevent four-year graduation. Our model involves an optimization formulation built upon the current curriculum and course offerings.

4 - Opportunities to Improve Education through Engineering Research

Kingsley A. Reeves, University of South Florida, Tampa, FL, 33620, United States, reeves@usf.edu, Grisselle Centeno

This talk introduces the theme of this session and highlights opportunities for the use of traditional industrial engineering methods to solve specific problems affecting the complex network of organizations, information or management systems, financing mechanisms, logistics, and personnel engaged in delivering education. In doing so, the presenters advocate for the creation of education engineering (EDEN) as a new research discipline.

5 - A Data-driven Approach to Investigating Student Persistence

Morgan Chesnicka, University of South Florida, Tampa, FL, United States, mchesnicka@mail.usf.edu, Kingsley Anthony Reeves

Student persistence (SP) is a key performance measure of student success. In this work, we develop a multi-source data-integrated database with predictive analytics tools to improve understanding of the multi-factorial nature of SP by extracting information from heterogeneous data resources. The developed data-driven predictive model is capable of identifying relevant promoting factors and/or barriers that may affect SP with improved prediction accuracy. The proposed work will help advance evidence-based understanding of SP and further inform more proactive university-wide decision-making for increasing the student retention rate and improving student success.

■ MB21

CC- Room 309

Emerging topics on OM-Finance interface

Sponsored: Manufacturing & Service Oper. Mgmt/iFORM

Sponsored Session

Chair: Jie Ning, Case Western Reserve University, Cleveland, OH, 44106, United States

1 - The Demand-side Explanation for the Great Recession

Yi Zhang, Illinois Institute of Technology, Chicago, IL, United States, John R. Birge

Various theories have been given as triggering events for the Great Recession of 2008-2009. Most explanations, however, ignore the operational characteristics of the market for securities. This talk will describe an operational model of the supply chain from investment institutions (particularly pension funds) to mortgage originators. We will show evidence that the changes in this supply chain that triggered the Great Recession originated at the downstream end of the supply chain and therefore represent a demand-side explanation.

2 - Financing for Responsible Operations

Xavier Warnes, Stanford University Graduate School of Business, Stanford, CA, 94305, United States, xwarnes@stanford.edu, Dan Andrei Iancu, Erica Plambeck

We discuss a set of problems in developing economies where responsible operations are intrinsically tied to the provision of responsible access to capital.

3 - The Impact of Trade Credit Provision on Retail Inventory

Christopher J. Chen, London Business School, London Business School, Regent's Park, London, NW14SA, United Kingdom, cchen@london.edu, Nitish Jain, S. Alex Yang

This paper examines the potential negative implication of limiting trade credit on inventory decisions at the retailer level. Using an empirical strategy that leverages: (i) an exogenous shock imparted by the French government's intervention to impose a ceiling on trade credit repayment; (ii) a triple difference-in-differences identification strategy; and (iii) Synthetic Controls, we estimate the causal impact of trade credit on firms' inventory stocking decisions. We find that, in retail sectors affected by the French regulation, the decrease in trade credit led to both an economically and statistically significant decline in firms' inventory levels.

4 - Trade Credit, Risk Shifting, and Buyer Firm Competition

Jie Ning, Case Western Reserve University, Department of Operations, 328 Peter B. Lewis Building, Cleveland, OH, 44106, United States, jie.ning@case.edu

Trade credit is widely used in practice and many theories have been proposed to explain that. In this paper, we propose a novel theory that connects the use of trade credit with risk shifting and buyer firm competition.

■ MB22

CC- Room 310

Consumer Returns and Retail Operations

Sponsored: Manufacturing & Service Oper. Mgmt/Sustainable Operations

Sponsored Session

Chair: Guangzhi Shang, Florida State University, Tallahassee, FL, 32306, United States

Co-Chair: Hailong Cui, University of Southern California, Los Angeles, CA, 90089-0809, United States

1 - The Rise of Ship-to-store: Theoretical and Empirical Analyses of its Impact on Retail Sales

Necati Ertekin, University of Minnesota, Department of OM&IS, Leavey School of Business, Minneapolis, MN, 95053, United States, Mehmet Gumus, Mohammad Nikoofal

We consider an emerging fulfillment model called Ship-to-Store (STS) that enables customers to ship their online purchases directly to a nearby store. We theoretically and empirically explore the implementation of STS services with respect to the disclosure of in-store product availability information.

2 - Measuring and Mitigating the Impact of Free Shipping Threshold Policy

Jiaqi Xu, Carnegie Mellon University, Tepper School of Business, 5000 Forbes Avenue, Pittsburgh, PA, 15213, United States, jiaqixu@andrew.cmu.edu, Gerard P. Cachon, Santiago Gallino

We develop a data-driven model to measure the financial impact of an online retailer's free shipping threshold policy. We consider the policy's effects on (i) customer activation, (ii) repeat purchase, and (iii) average profit per order. We apply the model to transaction data from an online retailer to offer recommendations.

3 - Consumer Return Policies in Omnichannel Operations

Leela Nageswara, University of Washington, Seattle, WA, 98195, United States, lnages@uw.edu, Soo-Haeng Cho, Alan Scheller-Wolf

We study the pricing and return policy decisions of an omnichannel retailer serving customers who differ in how they realize their valuation for a product — by inspecting in-store before purchase or by purchasing online and possibly returning misfit items. Our results show that generous refunds are driven by customer heterogeneity and the convenience of in-store returns. We find that omnichannel firms with good salvage partners as well as those with more store-based customers should offer full refunds. In contrast, firms with a significant store network and good in-store salvage opportunities should charge a fee for online returns in order to nudge customers to return in-store.

4 - Omnichannel Collaborations

Maryam M. Mahdikhani, Rutgers University, Newark, NJ, 07102, United States, m.mahdikhani@rutgers.edu, Tolga Aydinliyim, Monire Jalili

Motivated by partnerships between online and B&M retailers where the online retailer operates a micro store within the B&M store (e.g., Amazon within Kohl's), we study consumers' returns channel choice and induced B&M store customer traffic implications as well as when such partnerships are profitable for the involved parties.

■ MB23

CC- Room 3A

Inaugural Flash Session I (Decision Analysis)

Emerging Topic: Decision Analysis

Emerging Topic Session

Chair: Christian Wernz, Virginia Commonwealth University – VCU, Richmond, VA, 23298, United States

1 - Sourcing for Wind Power: Evidence from a Multifactor Analysis of the U.S. Electricity Industry

Ekundayo Shittu, George Washington University, Washington, DC, 20052, United States, eshittu@gwu.edu, Carmen B. Weigelt, Dor Hirsh Gai

We study how transaction costs with capability considerations such as the interaction between project development and ownership, power purchase agreements and state policy influence the make-or-buy decisions in the U.S. utilities industry. This is motivated by the surge in the adoption of wind energy in the upstream energy generation segment of the value chain where transaction hazards in contracting for wind power appear to be declining and capabilities related to the new segment accumulate affecting make-or-buy preferences. We show how resource proximity, timing of entry, and capability accumulation inform decisions over time under uncertainties in regulation for renewable energy.

2 - Evaluating the Trade-offs in Longitudinal Family Medicine Residency Schedules

Bjorn Berg, University of Minnesota, Minneapolis, MN, 55455, United States, bberg@umn.edu

Residency training in family medicine requires a comprehensive approach to care for a broad patient profile across a variety of settings. The current paradigm wherein residents progress through a series of month-long focused rotations is based on past precedent and draws from experienced understanding and perception of what works well. This research proposes to design and evaluate a new paradigm in family medicine residency training where a longitudinal schedule is used resulting in increased continuity and predictability in the clinic setting with their patients and care team and an elongated educational experience and exposure to specialty and hospital settings.

3 - Dynamic Modeling of Major Depressive Disorder and Marital Quality

Maede Maftouni, Virginia Tech, Blacksburg, VA, United States, Niyousha Hosseinichimeh, Andrea Wittenborn, Paula Fallas Valverde

Past studies showed reciprocal relations between marital quality and major depressive disorder. Depressive symptoms also increase financial hardship by reducing productivity and employment opportunities, at the same time, financial hardship increases depressive symptoms. Spouse support may alleviate some of the causes of distress but it may decline over time due to reduction in marital quality. We developed a simulation system dynamics model to examine reciprocal relations among these factors to understand their dynamic behaviors over time. Using the indirect inference method, we calibrated the model with the Fragile Families data and provided implications for practitioners.

4 - Behavior of FEMA Public Assistance Recipients with Repetitive Disaster Losses

Allison C. Reilly, University of Maryland, College Park, MD, 20017, United States, areilly2@umd.edu, Hamed Ghaedi

With nearly $100B in expenditures over the past two decades, FEMA'S Public Assistance Program is the largest disaster relief program for infrastructure in the US. In this work, we explore the behavior of infrastructure owners who file for disaster relief aid to quantify the role that repetitive losses have in filing decisions. We then make projections on how more frequent flooding events and behavioral adaptations to repetitive losses could escalate expenditures for FEMA.

5 - Decision Analysis: Past, Present, and Future

Ali E. Abbas, Professor, University of Southern California, Los Angeles, CA, 90089, United States, aliabbas@usc.edu

Decision Analysis is a normative approach to valuing and selecting decision alternatives. More than fifty years after the name was coined, there still exists some confusion about its application and especially to large systems and government enterprises. This talk will discuss recent developments in the field of decision analysis and will highlight some current opportunities and challenges of using Decision Analysis in large systems.

6 - Designing Sustainable Supply Chains

Jason R. W. Merrick, Virginia Commonwealth University, Richmond, VA, 23284, United States, jrmerric@vcu.edu

Government agencies contracting with private sector suppliers must balance economic performance with environmental sustainability. Suppliers try to interpret signals from prior bid decisions to form their most competitive bid. Working with a private company seeking to supply gasoline additives to the Brazilian federal government, we elicited the probability of winning the bid based on a deep knowledge of their potential competitors and the government's sustainability priorities. We then designed a distribution network to maximize expected revenue. These results provide insights to governments about how their priorities can incentivize greater improvements in sustainability.

7 - Forecasting the Cost of Offshore Wind: Expert Elicitation Versus Experience Curves

Erin Baker, Univ of Massachusetts-Amherst, Amherst, MA, 01003, United States, edbaker@ecs.umass.edu

We compare a formal expert elicitation with data-based experience curves, using offshore wind as a specific example. We find that experience curves predict lower costs than expert elicitations, and explore possible reasons why. We note that the experts' forecasts are consistent with the assumption that offshore wind is an offshoot of onshore wind, learning at a slower rate because it is farther on its experience curve.

■ MB24

CC- Room 3B

MCDM and Medicine / Healthcare: A Mutually Beneficial Relationship- II

Sponsored: Multiple Criteria Decision Making

Sponsored Session

Chair: Evangelos Triantaphyllou, Louisiana State University, Baton Rouge, LA, 70803, United States

Co-Chair: Juri Yanase, Complete Decisions, LLC, Baton Rouge, LA, 70810, United States

Co-Chair: Esra Buyuktahtakin Toy, New Jersey Institute of Technology, Newark, NJ, 07102, United States

1 - Multi-stage Stochastic Resource Allocation for the Optimal Control of Epidemic Diseases

Xuecheng Yin, New Jersey Institute of Technology, Newark, NJ, United States, xy276@njit.edu, Esra Buyuktahtakin-Toy

Existing compartmental models are limited in the optimization of resource allocation for controlling an epidemic outbreak. In this study, we address this core limitation and present a multi-stage stochastic programming epidemic compartmental model, which formulates spatio-temporally varying treatment rates based on an available budget. We apply this model to study the case of Ebola Virus Disease in West Africa to minimize an overall expected number of infected individuals, considering possible infection scenarios. Our model is practical, and can be adopted to study other infectious diseases in complex situations.

2 - Pandemic Influenza Vaccine Allocation with Equity

Osman Ozaltin, North Carolina State University, Industrial and Systems Engineering, Raleigh, NC, 27605, United States, oyozalti@ncsu.edu, Shakiba Enayati

We develop an age-structured influenza epidemic model with isolation. We then formulate a mathematical program to find an allocation policy that minimizes the vaccine stockpile needed to avoid a widespread infection. The proposed approach returns the optimal age-structured vaccine allocation rather than comparing the efficacy of just a few specific vaccination policies. Furthermore, we propose an equity constraint to help public health authorities integrate fairness in their vaccine allocation decisions

3 - Optimizing Multi-modal Cancer Treatment under 3D Spatio-temporal Tumor Growth

Eyyub Yunus Kibis, The College of Saint Rose, Albany, NY, 12203, United States, Esra Buyuktahtakin Toy

We introduce a new mixed-integer linear programming model that explicitly integrates the spread of cancer cells into a spatio-temporal model of cancer growth while taking into account treatment effects. The objective is to determine the optimal sequence of cancer treatment methods—surgery (S), chemotherapy (C), and radiotherapy (R)— as well as the optimal dosages for chemotherapy and radiation treatments while minimizing the newly generated tumor cells for early-stage breast cancer in a unique three-dimensional spatio-temporal system. The effectiveness of treatment combinations (i.e., SRC, SCR, CR, RC) are compared by tracking the number of cancer cells at the end of each treatment modality.

4 - Using MCDM to Determine the Best Treatment for Life-critical Diseases under Variable Health State Utility Scenarios

Juri Yanase, Complete Decisions, LLC, Baton Rouge, LA, 70810, United States, jurijuriy@aol.com, Evangelos Triantaphyllou

Some recent developments show that an MCDA approach that is based on maximizing QALYs (quality-adjusted life-years) and MAUT (multi-attribute utility theory) is the valid way to determine the best treatment when multiple treatments exist for life-critical diseases. A crucial role in such determinations is played by health state utilities (HSUs). Such quantities must satisfy certain consistency and independence assumptions. This talk describes a method based on quadratic optimization which offers a powerful way to decide what the best treatment is under various independence scenarios of HSU values. The proposed methodology is demonstrated with data related to non-metastatic prostate cancer.

■ MB25

CC- Room 401

Joint Session Not for Profit/PSOR: Application-Driven Research in Humanitarian, Health, and Non-Profit Operations

Emerging Topic: Humanitarian and NotforProfit Operations

Emerging Topic Session

Chair: Erica L. Gralla, George Washington University, Washington, DC, 20052, United States

1 - Implication of Abusive Leadership on Job Performance of Humanitarian Aid Workers

Mojtaba Salem, Kuhne Logistics University, Grosser Grasbrook 17, Hamburg, 20457, Germany, mojtaba.salem@the-klu.org, Maria Besiou, Niels Van Quaquebeke

Humanitarians may work under leaders who act aggressively towards them out of the belief that doing so will engender performance. While leadership research suggests this worsens performance, field reports show tough leaders can get the job done. This paper investigates factors that make humanitarian operations context resilient to destructive leadership.

2 - Ensuring Equity and Effectiveness Over Time in a Network for Good: a Multi-period Distribution Model for Food Banks with Stochastic Capacity

Irem Orgut, University of Alabama, Tuscaloosa, AL, United States, isorgut@cba.ua.edu, Julie Simmons Ivy, Reha Uzsoy

Based on our nine-year partnership with a local food bank, we address the equitable and effective distribution of food donations to charitable agencies with stochastic receiving capacities over a finite planning horizon. We develop a multi-period stochastic model that ensures equitable food distribution decisions by the food bank. We use the structural properties of this problem to obtain bounds on the optimal shipment amounts and develop heuristics. An extensive numerical study, based on data from our partner food bank, demonstrates the promising performance of the heuristics.

3 - A Network Design Problem Arising in the Restoration of the Water Supply System in Nepal

Marie-Eve Rancourt, HEC Montréal, Montréal, QC, Canada, marie-eve.rancourt@hec.ca, Gilbert Laporte, Jessica Rodriguez-Pereira, Selene Silvestri

We propose an optimization approach for the community water network rehabilitation problem targeting remote populations affected by the 2015 Nepal earthquake. To this end, we describe a new problem and a matheuristic developed to solve it. In this context, the primary objective of humanitarian organizations is to locate water taps such that people can access them accordingly to the national standards. The secondary objective consists of minimizing the cost to connect the water taps to the pipeline network. Since the water supply system is gravity-fed, the elevation has to be taken into account. Data provided by the Austrian Red Cross and satellite imagery are used to generate solutions.

4 - Kansas Healthcare Supply Chain Integrity: Mapping Vulnerabilities and Opportunities

Jessica L. Heier Stamm, Kansas State University, Manhattan, KS, 66503, United States, jlhs@k-state.edu, Camille Brown, Katherine Stachowiak, Michael McNulty

Continuity in care delivery during and after disasters is a key capability for healthcare organizations. Maintaining continuity depends on robust and resilient supply chains. We partnered with the Kansas Department of Health and Environment and the state's seven healthcare coalitions, through the federal Hospital Preparedness Program, to assess supply chain integrity for coalitions and their member organizations. This presentation describes the assessment process, including the online survey instrument used to gather supply chain information from healthcare coalition members statewide and next steps driven by the assessment.

5 - Approaches for Locating and Staffing FEMA's Disaster Recovery Centers

Erica L. Gralla, George Washington University, Washington, DC, 20052, United States, egralla@gwu.edu, Julia Nessa Moline, Jarrod D. Goentzel

FEMA has recently worked to make its operational decisions more data-driven. We worked with FEMA to develop two models for locating and staffing their temporary Disaster Recovery Centers. One model fits easily into FEMA's current decision-making process, while the other further improves service by challenging assumptions. Using data from three past disasters, we find cost savings of 75% on average while reducing travel time. We identify challenges and successes from the models' partial implementation, and draw insights on the potential for improving organizational decisions by developing models that either align with or challenge the decision-making culture.

■ MB26

CC- Room 4C-1

IBM Best Student Paper Award II

Sponsored: Service Science

Sponsored Session

Chair: Aly Megahed, IBM Research-Almaden, San Jose, CA, 95123, United States

Co-Chair: Paul R. Messinger, University of Alberta, Edmonton, AB, T6G 2R6, Canada

1 - IBM Best Student Paper Award

Paul R. Messinger, University of Alberta, Faculty of Business, 3-20e Faculty Of Business Bldg, Edmonton, AB, T6G 2R6, Canada, paul.messinger@ualberta.ca

From a highly competitive pool of submissions, a set of finalists has been selected by a panel of Service Science Section Leaders. In this session, these finalists will present their research findings to a panel of judges and a general audience. This award recognizes excellence among the section's student members and brings prestige to the Service Science Section as well as to the recipients honored.

■ MB27

CC- Room 4C-2

Behavioral Issues in Service Operations Management

Sponsored: Service Science

Sponsored Session

Chair: Sina Golara, Massachusetts Institute of Technology, Cambridge, MA, 02142, United States

1 - Learning Best Practices: Can Machine Learning Substitute for Experience?

Park Sinchaisri, The Wharton School, Philadelphia, PA, 19104, United States, swich@wharton.upenn.edu, Hamsa Sridhar Bastani, Osbert Bastani

An increasing number of domains are providing us with detailed trace data on human decisions in complex, dynamic environments. These decisions are often made by experts with deep experience in the task at hand. For example, nearly every physician action is logged in electronic medical record data; every movement of a driver is recorded on a ride-sharing platform; even store managers' decisions on daily pricing and inventory management are recorded. How can we leverage these large-scale logs of sequences of decisions and outcomes to identify better decision policies? We propose that machine learning algorithms are well suited to help supplement human decision-making in these applications.

2 - Multi-channel Delivery in Healthcare: The Impact of Telemedicine Centers in Southern India

Kraig Delana, London Business School, PhD Program Office, London, NW1 4SA, United Kingdom, kdelana@london.edu, Sarang Deo, Kamalini Ramdas

Telemedicine is increasingly used in rural communities across the developing world. However, the impact of telemedicine in these settings is not well understood. We analyze data from the Aravind Eye Care System in Southern India to examine the impact of opening telemedicine centers on access, treatments, and costs, at both the telemedicine center channel and the pre-existing hospital channel. We find evidence telemedicine centers improve access, particularly for patients with simple conditions, which contributes to an increase in the rates of glasses prescriptions. They also enable patients to substitute telemedicine center visits for hospital visits leading to savings in patient costs.

3 - Matching Dynamics in Highly Heterogenous Marketplaces

Ashish Kabra, University of Maryland-College Park, Robert H. Smith School of Busin, 7621 Mowatt Lane, College Park, MD, 20742, United States, akabra@rhsmith.umd.edu, Qingchen Wang

Several two-sided matching platforms exhibit a much larger heterogeneity in their demand and supply users (eg: Airbnb, TaskRabbit) compared to some of the other mainstream platforms (eg: Uber, Ofo). In collaboration with a large scale freelancer matching platform, we study the drivers of the match selection behavior using econometrics and machine learning methods.

■ MB28

CC- Room 4C-3

Pricing and Contracting under Uncertain Customer Perceptions

Sponsored: Service Science

Sponsored Session

Chair: Yimin Wang, Arizona State University, Tempe, AZ, 85287, United States

Co-Chair: Mei Li, PhD, Michigan State University, East Lansing, MI, United States

1 - Optimal Pricing under Customer Return Risk

Xiangjing Chen, PhD Candidate, Arizona State University, Tempe, AZ, United States, xchen328@asu.edu, Yimin Wang

We analyze a manufacturer's pricing strategy when customers' evaluation of product features is uncertain at the time of purchase. Customers' propensity to return the product depends on the realized fit of product features and the price paid. We characterize the optimal price and offer insights on how the risk of product returns influence the optimal pricing strategy.

2 - Management of Digital Innovative Services: Update Dynamics under Demand Uncertainty

Seongkyoon Jeong, Arizona State University, Business Administration, Tempe, AZ, 85281, United States, sjeong19@asu.edu, Adegoke Oke

Today, digital innovative services show distinct features from conventional products. Such services witness a rapid demand surge due to their innovativeness and a rapid decline and dissipation of demand as the service loses its appeal and innovativeness. The rapid decline of demand motivates service providers to replenish the demand by introducing major updates frequently due to supporting IT infrastructure. Using novel online game service data, this study shows that this practice leads to "saw-tooth" pattern of demand, which is synonymous with an inventory management profile, and that demand uncertainty plays a significant role in determining the demand replenishment point.

3 - Saving Outsourced Customer Service: Evolving Quality Uncertainty and Dynamic Monitoring Efforts

Yimin Wang, Arizona State University, W.P. Carey School of Business, Tempe, AZ, 85287, United States, Mei Li

Customer services play an important role for firms to retain customers and spur revenue growth. Many firms outsource customer services to third-party suppliers. We develop a normative model to investigate performance outcomes of outsourced customer services over a finite time horizon.

4 - Advance Selling in Video Games

Lifei Sheng, University of Houston Clear Lake, Houston, TX, United States, sheng@uhcl.edu, Xuying Zhao, Christopher Ryan

We study the pricing strategies of premium contents in video games. Players can purchase the premium contents in advance before the game starts or purchase in spot when they need them in the game. We find when the ratio of skilled players over non-skilled players among consumers is sufficiently large, the firm should adopt the pure advance selling strategy, which motivates all consumers buy early. Otherwise, the firm should adopt a hybrid advance selling strategy, where skilled players buy at spot while non-skilled players buy in advance. Moreover, we show that the firm benefits more from a game of chance, compared to a game of skill, because players are more homogeneous in the market in a game of chance.

■ MB29

CC- Room 4C-4

Matching Theory

Sponsored: Auction and Market Design

Sponsored Session

Chair: Thayer Morrill, North Carolina State University, Raleigh, NC, 27695, United States

1 - Stability in Matching Markets with Complex Constraints

Thanh Nguyen, Purdue University, West Lafayette, IN, United States

We consider a new model of many-to-one matching markets in which agents with multi-unit demand aim to maximize a cardinal linear objective subject to multidimensional knapsack constraints. The choice functions of agents with multi-unit demand are therefore not substitutable. As a result, pairwise stable matchings may not exist and, even when they do, may be highly inefficient. We provide an algorithm that finds a group-stable matching that approximately satisfies all the multidimensional knapsack constraints.

2 - A Theory of Simplicity in Games and Mechanism Design

Peter Troyan, University of Virginia, Charlottesville, VA, United States, petetroyan@gmail.com, Marek Pycia

We introduce a general class of simplicity concepts for games that vary the foresight abilities required of agents. Agents are presumed to be able to plan only for those histories that are viewed as simple from their current perspective (rather than all histories), and may update their strategic plan as the game progresses. For an action to be simply dominant, it must lead to unambiguously better outcomes, no matter what occurs at non-simple histories. We use our approach to characterize simple mechanisms in general social choice environments both with and without transfers, which includes canonical mechanisms such as ascending auctions, posted prices, and Random Priority.

3 - Pre-college Human Capital Investment and Affirmative Action, a Structural Policy Analysis of U.S. College Admissions

Aaron Bodoh-Creed, University of California-Berkeley, Berkeley, CA, United States, acreed@berkeley.edu, Brent R. Hickman

We estimate a model of college admissions wherein students endogenously accrue pre-college human capital (HC) as part of a contest for enrollment at high quality colleges. We identify the roles of school quality, HC, and students' privately known learning costs on post-college household income. Conditional on graduating, college quality is the most important factor in determining income, while unobserved student characteristics play a nontrivial secondary role. Pre-college HC drives college placement and graduation probability, but not post-college income. We also compare the status quo to a color-blind admissions rule and a proportional quota for minority students.

4 - Matching with Non-poaching

Umut Dur, NCSU, Raleigh, NC, 27695, United States, Mustafa Oguz Afacan

Non-poaching contracts prevent firms from hiring each other's employees. Not every worker-firm pair can match with each other even if they would rather do so. A constrained stability term is proposed. Stability is a special case of our constrained stability notion. We show that some properties of the stable matchings do not carry over to the constrained stable matchings. DA fails to be worker-optimal, yet it is the unique constrained stable and strategy-proof one. We propose 2 mechanisms. The first one is worker-optimal constrained stable and improves the workers' welfare upon that under DA. The second one is worker-optimal and assigns as many workers as possible subject to constrained stability.

5 - Partitionable Choice Functions

Thayer Morrill, North Carolina State University, Raleigh, NC, 27695, United States, Umut Dur, William Phan

We provide properties of choice functions that are necessary and sufficient for the existence of a stable assignment. Our results show that the substitutable domain is not the only one where stable assignments exist. Furthermore, these new types of choice functions have natural interpretations for real-life applications e.g. schools with multiple grades, hospitals and departments with different types of positions.

■ MB29a

CC- Room 400

Quantitative Risk Management

Sponsored: Finance

Sponsored Session

Chair: Chris Frei, University of Alberta, Edmonton, AB, Canada

Co-Chair: Abel Cadenillas, University of Alberta, Edmonton, AB, T6G 2G1, Canada

1 - From Hotelling to Nakamoto: The Economic Meaning of Bitcoin Mining

Steven Kou, Boston University, Questrom School of Business, Boston, MA, 02215, United States, Min Dai, Wei Jiang, Cong Qin

We proposed a model for Bitcoin mining from the miners' perspective, by extending the classical Hotelling model for exhaustible natural resources, via the addition of inventory and profits from Bitcoin transaction fees. The model is calibrated to the empirical data and dynamics of the average transaction fees.

2 - Forest Behind the Trees

Markus Pelger, Stanford University, Stanford, CA, 94305, United States, mpelger@stanford.edu, Svetlana Bryzgalova, Jason Zhu

Sorting-based strategy of building portfolios is the default empirical approach in asset pricing for creating both test assets and factor-mimicking returns. A natural limitation of this technique is its inability to adequately reflect the information contained in more than 2 characteristics and their interaction. We analyze the effect of a large number of characteristics on expected stock returns with decision trees. As a learning method for classification, the new approach is well-suited for building composite cross-sections of portfolios reflecting the rich conditional information contained in many characteristics and is a generalization of the conventional sorting-based strategies.

3 - Optimal Nonnegative Production

Abel Cadenillas, Professor, University of Alberta, Department of Mathematical Sciences, Edmonton, AB, T6G 2G1, Canada, abel@ualberta.ca

We consider an infinite horizon stochastic production planning problem with the constraint that the production rate must be nonnegative. We obtain an analytical solution for the optimal production policy.

4 - Digital Currencies: The Tradeoff Between Efficiency and Trust

Christoph Frei, University of Alberta, Mathematical and Statistical Sciences, CAB 621, Edmonton, AB, T6G 2G1, Canada, cfrei@ualberta.ca

Minimizing volatility in their exchange rates, new forms of digital currencies become viable alternatives to traditional currencies for payments. We develop a model to capture incentives and preferences behind the use of different payment methods in over-the-counter market transactions. Our model features the tradeoff between (i) welfare gains from lower transaction costs and (ii) costs of setting up the digital technology and trust concerns when using digital currencies. While participants in the digital currency benefit from welfare gains, people lacking trust in the digital currency suffer from fewer trading opportunities and decreased welfare when digital currencies become widely used.

■ MB30

CC- Room 6A

Tutorial: Health System Innovation: Analytics in Action

Emerging Topic: Tutorials

1 - Health System Innovation: Analytics in Action

Retsef Levi, Massachusetts Institute of Technology, Sloan School of Management, Cambridge, MA, 02142, United States, Martin S. Copenhaver, Michael Hu, Kyan Safavi, Ana Cecilia Zenteno Langle

This tutorial focuses on the implementation of data- and analytics-driven innovation in health systems. In particular, we focus on innovation around operations, system design, and optimization of large delivery systems. Additionally, the tutorial discusses a formal project management framework, general principles, and key success drivers that enable field implementations of high impact, analytics-driven projects. These discussions are specifically centered around facilitating collaboration between academics with analytics expertise, clinicians and administrative leaders in healthcare systems, as well as policy makers. To illustrate the usage of these ideas in practice, we describe three projects done in collaboration between Massachusetts General Hospital (MGH) and the Massachusetts Institute of Technology (MIT) Sloan School of Management.

■ MB31

CC- Room 6B

National Security Analytics

Sponsored: Military and Security

Sponsored Session

Chair: Robert T. Brigantic, Pacific Northwest National Laboratory, Richland, WA, 99352, United States

Co-Chair: Nick Betzsold, Pacific Northwest National Laboratory, Richland, WA, United States

Co-Chair: Samrat Chatterjee, Pacific Northwest National Laboratory

1 - Quantifying the Effectiveness of Border Security Investment

Jun Zhuang, Professor, University at Buffalo, SUNY, 317 Bell Hall, Buffalo, NY, 14260, United States, jzhuang@buffalo.edu, Ridwan Al Aziz

This research presents a comprehensive data-driven approach involving regression modeling, Principle Component Analysis, and Structural Equation Modeling to analyze the relationship among three groups of variables: (a) border security outcome metrics, input border security countermeasure metrics, and (c) external/environmental metrics. This project provides some novel insights on quantifying the effectiveness of border security counter-measures, and thereby facilitate more informed resource allocation in preventing drug/weapon smuggling, illegal migration, and terrorism.

2 - Risk Assessment and Security Measure Allocation for Optimal Aviation Security

Eva Lee, Georgia Tech, Industrial & Systems Engineering, Ctr for Operations Research in Medicine, Atlanta, GA, 30332-0205, United States, evalee-gatech@pm.me

This project establishes a quantitative construct for enterprise risk assessment and optimal portfolio investment to achieve the best aviation security. We first analyze and model the various aviation transportation risks and establish their interdependencies. Using the security measures and their capabilities, we formulate the multi-objective portfolio investment model via a mixed integer programming framework. The portfolio risk model determines the best capabilities of current budget. It can pinpoint potential capabilities when changes in budget occurs. This work is joint with TSA.

3 - Bayesian Predictive Threat Modeling Enhances Border Threat Detection

Dejan Neskovic, DHS S&T, Washington, DC, United States, Geoffrey Berlin

As the threat of illegal smuggling and entry along the Southern border continues to evolve, accurate and timely suspect threat classification is paramount. Using Bayesian analytics to make sense of our data-rich world in support of the law enforcement and homeland security is advantageous because it avoids making initial presumptions about relationships among data elements. Applying various machine learning algorithms and network scoring creates the best, most accurate and uncomplicated model. The DHS Science and Technology Directorate are developing a Bayesian Threat Model for the Air and Marine Operations Center (AMOC) as a decision support system bridging operations and strategic needs.

4 - Using Game Theory for Optimizing System Deterrence Strategies

Nick Betzsold, Pacific Northwest National Laboratory, Richland, WA, United States, nicholas.betzsold@pnnl.gov

In this presentation, we will discuss the use of signaling games as a modeling construct for optimizing deterrence-specific system strategies. Signaling games allow varying player beliefs and uncertainties to be modeled with an overarching goal to model deterrence as an outcome of a game where optimal adversary actions at equilibria conditions favor the defender. We begin with an overview of signaling games, including mathematical elements of such games. Next, selected perfect Bayesian equilibria solution strategies for these games will be presented. Finally, results from a numerical case study applied to a generic security venue with practical implementation takeaways will be discussed.

5 - Managing Information Security Investments under Uncertainty

Yueran Zhuo, Harvard Medical School, Boston, MA, United States, yzhuo1@mgh.harvard.edu
Yueran Zhuo, University of Massachusetts-Amherst, Amherst, MA, United States, YZHUO1@mgh.harvard.edu, Senay Solak

Information systems security has become an integral part of today's business operations. Firms are concerned with whether their investment portfolio is aimed towards maximizing returns, while also gradually come to acknowledge the importance of information sharing in information system security. In this presentation, we introduce our work on three practical problems related to information system security investment management which derive managerial insights for technology investment and information sharing decisions. The findings of our study help firms to improve the efficiency of information system security practice and better defend against attacks on their information properties.

■ MB32

CC- Room 6C

Daniel H. Wagner Prize II

Emerging Topic: Daniel H. Wagner Competition

Emerging Topic Session

1 - London Heathrow Airport Uses Real-Time Analytics for Improving Operations

Xiaojia Guo, University College-London, London, United Kingdom, Yael Grushka-Cockayne, Bert De Reyck

Improving collaborative decision-making is at the heart of airport operations centers (APOCs), recently established in major European airports. Our project's goal was to examine the opportunities offered by the co-location and real-time data sharing in the APOC at London's Heathrow airport. In the paper, we describe the process of how we chose the subject of a pilot, namely the improvement of transfer passenger flows through the airport, and how we helped Heathrow move from their legacy system for predicting passenger flows to an advanced machine learning based approach using real-time inputs. The framework we present can support the development and implementation of other data-driven systems.

2 - Ride-hailing Order Dispatching on DiDi via Reinforcement Learning

Zhiwei Qin, DiDi Research America, 450 National Ave, Mountain View, CA, 94043, United States, Xiaocheng Tang, Yan Jiao, Fan Zhang, Zhe Xu, Hongtu Zhu, Jieping Ye

Order dispatching (or order matching) is instrumental to the marketplace engine of a large-scale ride-hailing platform like DiDi. Due to the dynamic nature of supply and demand, the ride-hailing order dispatching problem is very challenging to solve over a long horizon. Added to the complexity are considerations of system performance and multi-objectives. In this paper, we describe the evolution of our approach to this optimization problem from a myopic combinatorial optimization approach to one that encompasses a semi-MDP model and deep reinforcement learning for long-term optimization.

■ MB33

CC- Room 602

Decomposition Methods

Sponsored: Optimization/Computational Optimization and Software

Sponsored Session

Chair: Matthew Galati, SAS Institute, Inc., Glen Mills, PA, 19342, United States

1 - Distributed Dantzig Wolfe Decomposition

Mohamed El Tonbari, Georgia Institute of Technology, Atlanta, GA, United States, Shabbir Ahmed

Dantzig-Wolfe decomposition (DWD) is a classical algorithm for solving large-scale linear programs which decomposes the problem into a master problem and a set of independent subproblems. Typically, the master problem is solved centrally, which can be undesirable or infeasible, such as in the case of decentralized storage of data or privacy issues. In this work, we propose a fully distributed DWD algorithm that relies on solving the master problem using a distributed consensus based ADMM algorithm. We derive error bounds on the optimality and feasibility gaps, and illustrate the validity of our algorithm using a Message Passing Interface (MPI) implementation.

2 - Decomposition Branching for Mixed Integer Programming

Baris Yildiz, Assistant Professor, Koc University, Istanbul, Turkey, Natashia Boland, Martin W. P. Savelsbergh

We introduce a novel and powerful approach for solving certain classes of mixed integer programs (MIPs): decomposition branching. Two seminal and widely used techniques for solving MIPs, branch-and-bound and decomposition, form its foundation. Computational experiments with instances of a weighted set covering problem and a regionalized p-median facility location problem with assignment range constraints demonstrate its efficacy: it explores far fewer nodes and can be orders of magnitude faster than a commercial solver.

3 - Learning Generalized Strong Branching for Set Covering / Packing and 0-1 Knapsack Problems

Yu Yang, Georgia Institute of Technology, Atlanta, GA, United States, yangyu@gatech.edu, Natashia Boland, Martin Savelsbergh, Bistra Dilkina

Set branching, a natural generalization of standard branching, branches on a set of variables, which potentially gives tighter local bounds and consequently yields smaller search trees. However, to decide a good set to branch on can be prohibitively time-consuming. Generalized Strong Branching on sets up to size k (GSB-k) considers sets of size no larger than k and chooses the set in a strong branching fashion. We apply machine learning techniques to learn GSB-2 and demonstrate that the learned branching method significantly outperforms CPLEX default branching on set covering/packing as well as 0-1 knapsack problems.

4 - Item Aggregation and Column Generation for Online-retail Inventory Placement

Annie I-An Chen, USC Marshall, Los Angeles, CA, 90064, United States, annieich@usc.edu, Stephen C. Graves

We study an online retailer's problem of selecting fulfillment centers for placing items so as to minimize costs. There can be millions of items, and fulfillment centers have fixed costs, so the resulting optimization problem has a large number of binary variables. We propose a large-scale optimization framework that aggregates items into clusters, solves the cluster-level problem with column generation, and disaggregates the solution into item-level placement plans. We develop an a priori optimality gap bound, and apply the framework to a numerical example with 1,000,000 items to show that it produces near-optimal solutions in a computationally efficient manner.

5 - Recent Progress in CPLEX Benders Decomposition

Andrea Tramontani, IBM Italy, Via Martin Luther King, 38/2, Bologna, 40132, Italy

In this talk we present the Benders decomposition branch-and-cut that is implemented in CPLEX for Mixed Integer Linear Programming (MILP). We illustrate the main algorithmic components behind our implementation and discuss the latest improvements that are currently work in progress. Finally, we present an extensive computational analysis on some classes of decomposable MILP problems, to assess the performance of Benders branch-and-cut in comparison with the default branch-and-cut of CPLEX. The results show that some models that are out of reach for a "standard" branch-and-cut can instead be solved by Benders decomposition.

■ MB34

CC- Room 603

Polynomial Optimization

Sponsored: Optimization/Global Optimization

Sponsored Session

Chair: Cemil Dibek

Co-Chair: Bachir EL Khadir, Princeton, NJ, 08540, United States

1 - Sudoku via Optimization

Robert J. Vanderbei, Professor, Princeton University, Operations Research & Financial Engineering, Princeton, NJ, 08544, United States, rvdb@princeton.edu

Optimization tools can be used to create and solve Sudoku problems. The simplest formulation of a solver is as an integer programming problem. But, if the problem is known to have a unique solution, as is the case in real Sudoku problems, then the solution can be found by solving a linear optimization problem. We will discuss these formulations and, if time permits, also discuss how to generate Sudoku problems that have a unique solution.

2 - Implicit Regularization for Solving Random Quadratic Systems of Equations

Yuxin Chen, Princeton University, Princeton, NJ, 08540, United States, Cong Ma, Kaizheng Wang, Yuejie Chi

Recent years have seen a flurry of activities in designing efficient nonconvex procedures for solving quadratic systems of equations. The state-of-the-art procedures often require proper regularization to ensure fast convergence. However, prior theory either recommends highly conservative learning rates to avoid overshooting, or completely lacks performance guarantees. This work uncovers a striking phenomenon: even in the absence of explicit regularization, GD enforces proper regularization implicitly. This “implicit regularization” feature allows GD to proceed far more aggressively without overshooting, which results in substantial computational savings.

3 - Learning Dynamical Systems with Side Information

Bachir EL Khadir, Princeton University, Princeton, NJ, 08540, United States, bkhadir@princeton.edu, Amir Ali Ahmadi

We study the problem of learning dynamical systems from very limited data but in presence of “side information”, such as physical laws or contextual knowledge. This is motivated by safety-critical applications where an unknown dynamical system needs to be controlled after a very short learning phase where a few of its trajectories are observed. (Imagine, e.g., the task of autonomously landing a passenger airplane that has gone through sudden wing damage.) We show that sum of squares optimization is particularly suited for exploiting side information in order to assist the task of learning when data is limited.

4 - An Algebraic Perspective on Perfect Graphs

Cemil Dibek, Princeton University, Princeton, NJ, 08540, United States, Amir Ali Ahmadi

For a graph G=(V,E) with clique number (G), if we define the quartic form bG(x) in the variables x=(x1, ..., x|V(G)|)T by bG(x) = -2 (G) ∑ xi2xj2 + ((G) - 1) (∑ xi2)2, then the Motzkin-Straus theorem implies that bG(x) is nonnegative. In this work, we introduce the notion of sos-perfectness. A graph G is perfect if for every induced subgraph H, the chromatic number of H equals the clique number of H. A graph G is sos-perfect if bH(x) is a sum of squares (sos) for every induced subgraph H of G. We show that a graph is perfect if and only if it is sos-perfect. This equivalence together with the strong perfect graph theorem allows us to explicitly provide an infinite family of nonnegative polynomials that are not sos.

■ MB35

CC- Room 604

Topics in Integer Programming and Combinatorial Optimization

Sponsored: Optimization/Integer and Discrete Optimization

Sponsored Session

Chair: Akshay Gupte, Clemson University, Clemson, SC, 29634-0975, United States

1 - Partial Symmetries and Grid-free Algorithms for Cut-generating Functions

Matthias Koeppe, University of California-Davis, Dept of Mathematics, Davis, CA, 95616, United States, mkoeppe@math.ucdavis.edu, Robert Hildebrand, Yuan Zhou

The infinite group problem is an infinite-dimensional model that provides the coefficients of general-purpose cutting planes to integer programs via cut-generating functions (CGFs). For any CGF, we define a space of perturbation functions, improving directions that strengthen (lift) the CGF. If the space is trivial, the CGF is extreme. We express partial symmetries of perturbations using inverse semigroup actions. We provide a complete characterization of the space of perturbations and the foundation for grid-free algorithms for cut-generating functions. We benchmark our implementation of these methods against earlier, grid-based algorithms related to Gomory’s finite group problem.

2 - Algorithms for Discrepancy Minimization

Thomas Rothvoss, University of Washington, Seattle, WA, 98103, United States, rothvoss@uw.edu

A classical theorem of Spencer shows that any set system with n sets and n elements admits a coloring of discrepancy O(n^1/2). Recent work of Bansal, Lovett and Meka shows that such colorings can be found in polynomial time. We continue this exciting line of research and present two new algorithms: (1) We present a deterministic polynomial time algorithm for finding colorings in the Lovett-Meka setting. The algorithm is based on the Multiplicative Weight Update Method. (2) We also prove that a surprisingly simple randomized algorithm can find a partial coloring in a symmetric convex set with large enough Gaussian measure in polynomial time. This is joint work with Avi Levy and Harish Ramadas.

3 - Approximability of Constrained Submodular and Subadditive Maximization

Akshay Gupte, Clemson University, Dept. of Mathematical Sciences, Clemson, SC, 29634-0975, United States, agupte@clemson.edu

We prove that maximizing a submodular function subject to arbitrary number of $\le$ and $\ge$ easy knapsack constraints is NP-hard to approximate within factor 0.6622 \sqrt{n}/(2(log n)^(0.75 + eps)) for arbitrary eps > 0. “Easy” refers to knapsacks for which the cover relaxation is integral. If the number of easy constraints is bounded by a constant, then the complexity is O(poly(n) K) where K is the complexity of submodular maximization over the remaining set of constraints. We also give a simple rounding algorithm that for any constant k >= 1 gives a factor n/k approximation for maximizing a subadditive function over multiple matroid constraints.

4 - Fair Dimensionality Reduction and Iterative Rounding for SDPs

Uthaipon (Tao) Tantipongpipat, PhD candidate, Georgia Institute of Technology, Atlanta, GA, United States, Samira Samadi, Mohit Singh, Jamie Morgenstern, Santosh Vempala

We model “fair” dimensionality reduction as an optimization problem. A central example is the fair PCA problem: an input data is divided into k groups, and the goal is to find a single d-dimensional representation for all groups for which the maximum variance (or minimum reconstruction error) is optimized for all groups in a fair (or balanced) manner. We give an exact polynomial-time algorithm for k=2 groups. The result relies on extending results of Pataki (1998) regarding rank of extreme point solutions to semi-definite programs. This approach generalizes to any monotone concave function of the individual group objectives and general d,k with O(sqrt(k)) violation in the number of target dimension d.

■ MB36

CC- Room 605

Data-Driven Optimization Under Uncertainty

Sponsored: Optimization/Optimization Under Uncertainty

Sponsored Session

Chair: Dimitris Bertsimas, Massachusetts Institute of Technology, Cambridge, MA, 02139, United States

1 - Dynamic Optimization with Side Information

Bradley Sturt, Massachusetts Institute of Technology, Cambridge, MA, 02144, United States, bsturt@mit.edu, Dimitris Bertsimas

We present a scalable approach for leveraging machine learning in dynamic optimization under uncertainty. Our approach finds policies by solving a robust optimization problem with multiple uncertainty sets, which are constructed using historical data and machine learning (such as random forests and kNN). Through a novel concentration inequality, we show that the policies have near-optimal average performance in big data settings (w.p.1) and can be tractably approximated using overlapping linear decision rules. Across examples from inventory management and finance with over ten stages, our method finds policies in under one minute which outperform alternatives by 15%.

2 - Distributionally Robust Risk Measures with Structured Wasserstein Ambiguity Sets

Viet Anh Nguyen, Ecole Polytechnique Federale de Lausanne (EPFL), OD Y. 1.19, Station 5, Lausanne, 1015, Switzerland, Soroosh Shafieezadeh-Abadeh, Damir Filipovic, Daniel Kuhn

By injecting structural information about the unknown true distribution of the uncertain problem parameters into the outer approximation of the Wasserstein ambiguity set, we obtain several new optimization problems where the decision maker is minimizing risk measures such as the Value-at-Risk, the Conditional Valueat-Risk or the entropic risk measure.

3 - Data Analytics with B(R)agging Prediction Models

Bart Paul Gerard Van Parys, MIT Sloan School of Management, Cambridge, MA, 02139, United States

Boostrap aggregation or bagging is a well known statistical tool which increase the power of statistical predictions. In this presentation we generalize bagging methods to data-driven decision-making as well. In particular, we discuss how bootstrap robust aggregation (bragging) methods can make robust decisions based directly on supervised data. In addition, we reveal how bragging formulations are intimately related to distributionally robust optimization. Crucially, our bragging methods are computationally tractable and are interpretable.

4 - Optimization over Continuous and Multi-dimensional Decisions with Observational Data

Christopher G. McCord, Massachusetts Institute of Technology, Cambridge, MA, 19711, United States, mccord@mit.edu

We consider the optimization of an uncertain objective over continuous and multi-dimensional decision spaces in problems in which we are only provided with observational data. We propose a novel algorithmic framework that is tractable, asymptotically consistent, and superior to comparable methods on example problems. Our approach leverages predictive machine learning methods and incorporates information on the uncertainty of the predicted outcomes for the purpose of prescribing decisions. We demonstrate the efficacy of our method on examples involving both synthetic and real data sets.

■ MB37

CC- Room 606

Distributionally Robust Optimization: Modeling, Algorithms, and Applications II

Sponsored: Optimization/Optimization Under Uncertainty

Sponsored Session

Chair: Kibaek Kim, Argonne National Laboratory, Lemont, IL, 60439, United States

Co-Chair: Anirudh Subramanyam, Argonne National Laboratory, Lemont, IL, 60302, United States

1 - Computationally Efficient Approximations for Distributionally Robust Optimization

Jianqiang Cheng, University of Arizona, Tucson, AZ, 85721, United States, jqcheng@email.arizona.edu, Meysam Cheramin, Ruiwei Jiang

Many distributionally robust optimization (DRO) instances can be formulated as semidefinite programming (SDP) problems. However, SDP problems in practice are computationally challenging. In this talk, we present computationally efficient (inner and outer) approximations for DRO problems based on the idea of the principal component analysis (PCA). We also derive theoretical bounds on the gaps between the original problem and its PCA approximations. Furthermore, an extensive numerical study shows the strength of the proposed approximations in terms of solution quality and runtime.

2 - Multistage Distributionally Robust Mixed-integer Programming with Decision-dependent Ambiguity Sets

Siqian Shen, Associate Professor, University of Michigan, Industrial & Operations Engineering, Ann Arbor, MI, 48109, United States, siqian@umich.edu, Xian Yu

We study multistage distributionally robust optimization models with integer variables and endogenous uncertainty. We consider ambiguity sets defined by 1) decision-dependent bounds on the moments, 2) exact decision-dependent mean and covariance, and 3) ambiguous mean and covariance that lie in an ellipsoid and a positive semidefinite cone, respectively. We apply McCormick envelopes and inner approximation of positive semidefinite cones to recast the subproblem in each stage as a mixed-integer linear program and then apply Stochastic Dual Dynamic integer Programming (SDDiP). We test instances of the decision-dependent multistage facility location problem to demonstrate the results.

3 - Tractable Reformulations of Distributionally Robust Two-stage Stochastic Programs with ∞-Wasserstein Distance

Weijun Xie, Virginia Tech, Department of Industrial and Systems Engineering, Blacksburg, VA, 24061, United States, wxie@vt.edu

This paper studies distributionally robust two-stage stochastic programs (DRTSP) with ∞-Wasserstein distance by providing sufficient conditions under which the worst-case expected recourse function in DRTSP can be efficiently computed via a tractable convex program. The developed reformulation techniques are extended to DRTSP with binary random parameters. The main tractable reformulations in this paper are projected into the original decision space and thus can be interpreted as conventional two-stage stochastic programs under discrete support with extra penalty terms enforcing the robustness. These tractable results are further demonstrated to be sharp through complexity analysis.

4 - Nurse Staffing under Uncertain Demand and Absenteeism

Minseok Ryu, University of Michigan, Ann Arbor, MI, 48105, United States, msryu@umich.edu, Ruiwei Jiang

This paper describes a data-driven approach for nurse staffing decision under uncertain demand and absenteeism. We propose a distributionally robust nurse staffing (DRNS) model with both exogenous (stemming from demand uncertainty) and endogenous uncertainty (stemming from nurse absenteeism). We provide a separation approach to solve the DRNS model with general nurse pool structures. Also, we identify several classes of nurse pool structures that often arise in practice and show how the DRNS model in each of these structures can be reformulated as a monolithic mixed-integer linear program that facilitates off-the-shelf commercial software. Also, we propose an optimal nurse pool design model.

■ MB38

CC- Room 607

Stochastic Programming on Power Systems with Uncertainty

Sponsored: Optimization/Optimization Under Uncertainty

Sponsored Session

Chair: Yiling Zhang, University of Michigan, Ann Arbor, MI, 48105, United States

1 - Distributionally Robust Chance Constrained Optimal Power Flow Assuming Unimodal Distributions with Misspecified Modes

Bowen Li, Argonne National Laboratory, Lemont, IL, 48105, United States, bowen.li@anl.gov, Ruiwei Jiang, Johanna Mathieu

Recent OPF works have explored distributionally robust chance constraints, in which the constraints are satisfied over a set of distributions called the ambiguity set. Commonly, ambiguity sets contain only moment-based information; however, specifying additional characteristics such as the unimodality information can reduce conservatism and cost. In practice, it is difficult to estimate the mode location from the data and so we allow it to be potentially misspecified. We formulate the problem and derive a separation-based algorithm to efficiently solve it. With simulations, we find that a misspecified mode significantly affects the reliability of the solution.

2 - Benders Decomposition with Projection Cuts – A Case Study on Two-stage Stochastic Unit Commitment Problem

Haoming Shen, University of Michigan, Ann Arbor, MI, United States, Ruiwei Jiang

We study a class of two-stage stochastic linear programs and their solution via Benders decomposition. In particular, we propose a family of cutting planes, termed the projection cuts (PCs), for accelerating the Benders decomposition. Through incorporating the structural information of the second-stage formulation, PCs could help reduce the number of feasibility cuts involved in Benders. In a case study, we apply PCs to the stochastic unit commitment test instances and report promising results.

3 - Temporal and Spatial Decomposition of Power System Planning Problems

Antonio J. Conejo, The Ohio State University, Department of Integrated Systems Engineering, Columbus, OH, 43210, United States, conejonavarro.1@osu.edu, Ramteen Sioshansi

Power system planning problems are becoming increasingly challenging. High renewable penetration levels complicate the problem in two ways. First, accurate uncertainty modelling requires require short- and long-term uncertainties to be captured. Second, economic renewable integration requires greater use of spatially diverse resources, thereby increasing the physical footprint of planning problems. In this talk, we explore the use of decomposition techniques (e.g., efficient variants of Lagrangian relaxation and Benders's decomposition) to tackle this important problem by exploiting its temporal and spatial structures.

4 - Distributionally Robust Building Load Control to Compensate Fluctuations in Solar Power Generation

Yiling Zhang, University of Michigan, Ann Arbor, MI, 48105, United States, zyiling@umich.edu, Jin Dong, Teja Kuruganti, Siqian Shen, Yaosuo Xue

This paper investigates the use of a collection of dispatchable heating, ventilation, and air conditioning (HVAC) systems to absorb low-frequency fluctuations in renewable energy sources, especially in solar photovoltaic (PV) generation. Given the uncertain and time-varying nature of solar PV generation, its probability distribution is difficult to be estimated perfectly. We formulate a distributionally robust chance-constrained model to ensure that PV generation is consumed with a desired probability for an ambiguity set based on moment information. We show that the DRCC model achieves constantly good performance even in the case with the presence of probability distribution ambiguity.

■ MB39

CC- Room 608

Round Table – Positive Train Control

Sponsored: Railway Applications

Sponsored Session

Chair: Jeremiah Dirnberger, GE Transportation, Jacksonville, FL, 32217, United States

Moderator

Jeremiah Dirnberger, Product Manager, Wabtec Corporation, Jacksonville, FL, 32217, United States, jeremiah.dirnberger@wabtec.com

Positive Train Control (PTC) is one of the largest infrastructure projects ever undertaken by a single industry. Mandated by the U.S. government, PTC aims to further reduce the risk of accidents on the nation's rail network. The amount of data collected for the operation of this system is unprecedented and the industry is looking to leverage it to create the backbone of a digital railroad. In these panels, experts from several leading will discuss the potentials within this new data, how it is already being used, the opportunity for data scientists and operations researchers, and its role in the path toward automation in the rail industry.

Panelists

- Larry Chalmers, Wabtec Corporation
- Marty Schlenker, BNSF Railway, Fort Worth, TX, United States
- Patricia Randall, Princeton Consultants, Greenville, SC, 29605, United States
- Steven Harrod, Technical University of Denmark, Lyngby, 2800, Denmark

■ MB40

CC- Room 609

Optimization Perspectives on Reinforcement Learning

Sponsored: Optimization/Nonlinear Programming

Sponsored Session

Chair: Alec Koppel, U.S. Army Research Laboratory, Silver Spring, MD, 20910, United States

1 - Provably Efficient Reinforcement Learning with Linear Function Approximation

Zhuoran Yang, Princeton University, Princeton, NJ, 08544, United States

The introduction of function approximation in RL raises a fundamental set of challenges involving computational and statistical efficiency, especially given the need to manage the exploration/exploitation tradeoff. As a result, a core RL question remains open: how can we design provably efficient RL algorithms that incorporate function approximation? In this talk, we present the first provable RL algorithm with both polynomial runtime and polynomial sample complexity in the setting with linear dynamics and linear rewards, where linear value functions are adopted. Without requiring a "simulator" or additional assumptions, we prove that an optimistic modification of Least-Squares Value Iteration (LSVI) achieves O(\sqrt{d^3H^3T}) regret, where d is the ambient dimension of feature space, H is the length of each episode, and T is the total number of steps. Importantly, such regret is independent of the number of states and actions. This is based on a joint work with Chi Jin, Zhaoran Wang, and Michael Jordan.

2 - Global Convergence of Policy Gradient Methods: A Nonconvex Optimization Perspective

Alec Koppel, Research Scientist, U.S. Army Research Laboratory, 8710 Cameron street apt 1509, Adelphi, MD, 20910, United States

Reinforcement Learning (RL) has gained popularity recently with the success of AlphaGo besting the world champion in Go during summer 2016. However, recent successes of RL have been called into question due to high variance across training runs. Motivated by this gap, we spotlight efforts to solidify theoretical understanding of the rate analysis and limiting properties of policy gradient (PG) methods in continuous Markov Decision Problems from a non-convex optimization perspective. Moreover, we design modified step-size rules that yield convergence to local extrema under additional hypotheses on the reward. These results yield a framework for the future design of stable and reliable RL tools.

3 - Plan Online Learn Offline: Efficient Learning and Exploration via Model-based Reinforcement Learning

Aravind Rajeswaran, PhD Student, University of Washington, Seattle, WA, United States, aravraj@cs.washington.edu

We propose a plan online and learn offline (POLO) framework for the setting where an agent, with an internal model, needs to continually act and learn in the world. Our work builds on the synergistic relationship between local model-based control, global value function learning, and exploration. We study how trajectory optimization copes with approximation errors in the value function and stabilizes training. Conversely, we also study how value functions can help reduce planning horizon. Finally, we also demonstrate how and why planning is a critical component for efficient exploration.

4 - Target-based Temporal-difference and Q-learning

Donghwan Lee, Postdoctoral Associate, University of Illinois, Urbana-Champaign, Urbana, IL, United States, donghwan@illinois.edu, Niao He

In this work, we introduce a new family of target-based temporal difference (TD) learning algorithms and provide theoretical analysis on their convergence. In contrast to the standard TD-learning, target-based TD algorithms maintain two separate learning parameters{the target variable and online variable. Particularly, we introduce three members in the family, called the averaging TD, double TD, and periodic TD, where the target variable is updated through an averaging, symmetric, or periodic fashion, mirroring those techniques used in deep Q-learning practice. We establish asymptotic convergence analyses for both averaging TD and double TD and a finite sample analysis for periodic TD. Finally, we briefly discuss the Q-learning extension of the target-based TD learning.

■ MB41

CC- Room 610

Conic Optimization III

Sponsored: Optimization/Linear and Conic Optimization

Sponsored Session

Chair: Palma London, Caltech, 1200 E. California Blvd., Pasadena, CA, 91125, United States

1 - Computational Experience with a Modified Potential Reduction Algorithm for Conic Optimization

KuoLing Huang, Principal Scientist, Anthem, Inc., Chicago, IL, United States, jupiters1117@gmail.com

We present a homogeneous algorithm equipped with a modified potential function for solving conic optimization problems. The potential function described here ensures a global linear polynomial-time convergence while providing the flexibility to integrate heuristics for generating the search directions and step length computations. A practical algorithm based on this potential function is implemented in a free software package named Colin. Computational results on standard test problems against other mature software packages will be discussed.

2 - Lower Bounds for Parallel and Randomized Convex Optimization

Cristobal Guzman, PUC-Chile, Santiago, Chile, Jelena Diakonikolas

We study the question of whether parallelization in the exploration of the feasible set can be usedto speed up convex optimization, in the local oracle model of computation. We show that the answer is negative for both deterministic and randomized algorithms applied to essentially any of the interesting geometries and nonsmooth, weakly-smooth, or smooth objective functions. In particular, we show thatit is not possible to obtain a polylogarithmic (in the sequential complexity of the problem) number of parallel rounds with a polynomial (in the dimension) number of queries per round.

3 - The Outcome Range Problem: Exact and Approximation Methods

Mohsen Mohammadi, University of Louisville, Louisville, KY, United States, m0moha15@louisville.edu, Monica Gentili, Milan Hladík

We consider the linear programming problem in which all or some of input data can vary within given real intervals. Determining the set of all optimal solutions arising from all perturbations of uncertain data has been a problem of interest in this topic. We introduce, in this context, the outcome range problem which consists of determining the best and the worst values of a given (additional) linear function over the set of all optimal solutions of a linear program with interval data. We formally define the problem and address its complexity. We then investigate lower and upper bound approximation for the problem. We also propose a branch and bound based algorithm to solve the problem to optimality.

4 - An Acceleration Framework for Packing Linear Programs

Palma London, Caltech, Pasadena, CA, United States, plondon@caltech.edu, Shai Vardi, Adam Wierman, Hanling Yi

This paper presents an acceleration framework for packing linear programming problems where the amount of data available is limited, i.e., where the number of constraints m is small compared to the variable dimension n. The framework can be used as a black box to speed up linear programming solvers dramatically, by two orders of magnitude in our experiments. We present worst-case guarantees on the quality of the solution and the speedup provided. The framework can be used to accelerate exact solvers, approximate solvers, and parallel/distributed solvers. Further, it can be used for both linear programs and integer linear programs.

■ MB42

CC- Room 611

Cliques, Relaxations, and Interdiction

Sponsored: Optimization/Network Optimization

Sponsored Session

Chair: Balabhaskar Balasundaram, Stillwater, OK, 74078, United States

Co-Chair: Juan Sebastian Borrero, Oklahoma State University

1 - Fault-tolerant S-clubs

Yajun Lu, Bucknell University, Industrial Engineering & Manag, Lewisburg, PA, 74078, United States, Hosseinali Salemi, Baski Balasundaram, Austin Buchanan

Cliques and their graph-theoretic generalizations are frequently used to model tightly knit clusters in graphs. One such model is the s-club, a vertex set that induces a subgraph of diameter at most s. As low diameter requires the presence of short paths in the induced subgraph, this property is not hereditary on vertex-induced subgraphs. The pursuit of a "robust" extension of the s-club model spawned the r-robust s-club model variant that we discuss in this talk. We address the complexity of the feasibility testing and optimization problems associated with these variants, propose cut-like formulations, and explore algorithmic ideas to solve benchmark instances with several thousand vertices.

2 - Clique and 2-club Signatures

Hao Pan, Oklahoma State University, Stillwater, OK, 74074, United States, hao.pan@okstate.edu, Baski Balasundaram, Juan Sebastian Borrero

We introduce the notion of graph signature in a finite sequence of graphs that can accommodate multiple graph-theoretic structures simultaneously in order to describe a persistent pattern in a sequence of graphs. This modeling framework is motivated by the need to detect a subset of vertices that model for instance, a cohesive social subgroup in a series of "snapshots" of a social network that is evolving over time. In this setting we assume that the subgraphs of interest may not all look alike in the snapshot graphs. We formulate the general problem and propose an algorithmic framework that we investigate computationally for clique and 2-club signatures.

3 - Blocking Cliques via Edge Removals

Foad Mahdavi Pajouh, University of Massachusetts Boston, Boston, MA, United States, Foad.Mahdavi@umb.edu

The minimum cost edge blocker clique problem (EBCP) is introduced as the problem of removing a minimum cost subset of edges in a graph so that each clique's weight is bounded above by some threshold. Large-weight cliques effectively model clusters of important actors with quick communications in real-world settings such as social, communication, and biological systems. This talk presents complexity results, polyhedral results, and two exact algorithms for this problem. Computational results of solving EBCP on a collection of random graphs and power-law real-world networks by using our proposed exact algorithms are also provided.

4 - Perfect Neighbor Sets in Graphs

Umur Hastürk, Middle East Technical University, Ankara, Turkey, hasturk@metu.edu.tr, Mustafa Kemal Tural

In this study, we examine perfect neighborhood sets in undirected graphs. We propose two integer programming formulations for the problem and these formulations are made stronger with additional valid inequalities. Then, we conduct computational experiments to see the effect of these valid inequalities for different graph classes and for both weighted and unweighted objective functions.

5 - Minimum-cardinality Balanced Edge Addition in Polarized Networks: Formulation and Solution Approaches

Celso C. Ribeiro, Universidade Federal Fluminense, Rio de Janeiro, Brazil, Ruben Interian, Jorge R. Moreno

The node set V of a polarized network is divided into two or more strongly connected groups, with few inter-group edges. The minimal intervention principle assumes that a small number of changes should be made in the network to reduce polarization. The Minimum-Cardinality Balanced Edge Addition Problem seeks to minimize the number of edges to be added to a polarized network in order that any vertex of a vertex subset A can reach a vertex of V-A by a path with a limited number of edges in the resulting network. Integer programming and heuristic approaches and numerical results are presented.

■ MB43

CC- Room 612

Joint Session ICS/Opt. Integer & Discrete: Integration of Discrete Optimization and Machine Learning

Sponsored: Computing

Sponsored Session

Chair: Elias B Khalil, Atlanta, GA, 30309, United States

1 - Decision-focused Learning for Combinatorial Optimization

Bistra Dilkina, University of Southern California, 941 Bloom Walk, Los Angeles, CA, 90089, United States, Bryan Wilder, Aaron Ferber, Milind Tambe

In many real-world setting, we use ML models to estimate values that play a role in a downstream combinatorial optimization task. We propose a Decision-Focused Learning framework which melds the data-decisions pipeline by integrating prediction and combinatorial optimization into a single end-to-end system. The predictive model is trained using the quality of the decisions which it induces via the optimization algorithm. We show how the framework applies to predicting objective coefficient values for combinatorial problems that can be represented as linear programs (LPs) or as mixed integer linear programs (MILPs).

2 - Optimal Sparse Decision Trees

Cynthia Rudin, Duke, LSRC / Box 90129, Durham, NC, 27708, United States

The problem of computing optimal sparse decision trees is one of the oldest problems in artificial intelligence. Its solution has implications for interpretable machine learning. It is also extremely hard in practice. I will present an algorithm that achieves superior performance on the problem of sparse, binary-split decision trees for categorical variables. This algorithm is several orders of magnitude faster than prior approaches. Joint work with Xiyang Hu and Margo Seltzer.

3 - Embedding Constraint Reasoning in Machine Learning via Decision Diagrams

Yexiang Xue, Purdue University, Institute for Computational Sustainability, 344 Gates Hall, West Lafayette, IN, 14853-7501, United States, yexiang@purdue.edu, Willem-Jan Van Hoeve

The emergence of large-scale constraint reasoning and machine learning have led to a number of successful applications. Yet, a few applicational domains still remain out of reach of constraint reasoning or machine learning, when applied in isolation. To leverage the capabilities of both technologies, we propose an integrated method that Embeds Constraint Reasoning in Machine Learning (ECOR-ML). The core idea is to augment machine learning algorithms with a constraint reasoning module that represents operational constraints. By enforcing the constraints, the output of generative models can now provide assurances of safety, correctness, and/or fairness.

4 - The Voice of Optimization

Bartolomeo Stellato, Massachusetts Institute of Technology, MIT, Cambridge, MA, United States, stellato@mit.edu, Dimitris Bertsimas

We present a machine learning approach to predict the strategy behind the optimal solution of mixed-integer convex optimization problems. Using interpretable algorithms such as optimal classification trees (OCTs) we gain insights on the relationship between the problem parameters and the optimal solution. In this way, optimization is no longer a black-box and we can understand it. Moreover, using machine learning classifiers such as OCTs or neural networks (NNs), our method is able to compute optimal solutions at very high speed. We benchmark our approach on several examples obtaining accuracy above 90% and computation times multiple orders of magnitude faster than state-of-the-art solvers.

■ MB44

CC- Room 613

Decomposition Approaches in Integer Programming

Sponsored: Computing

Sponsored Session

Chair: Mucahit Cevik, Ryerson University, Toronto, ON, Canada

1 - Subtree Decomposition Method for Multistage Stochastic Programs

Rahman Khorramfar, NC state University, Raleigh, NC, 27606, United States, Osman Ozaltin

Considering the general multi-stage stochastic problem, this research develops a bounding framework based on the decomposition of the scenario tree. The framework is essentially a grouping methodology which systematically divides the scenario tree into sub-trees where each of them is amenable for commercial solvers. The independence of sub-trees allows computational parallelism. Therefore, the proposed framework can accommodate large-sized instances of Multi-stage Capacity Acquisition Problem (MCAP) with millions of scenarios and obtains tight bounds.

2 - A Decomposition Approach to Solve the Selective Graph Coloring Problem in Perfect Graphs

Oylum Seker, University of Toronto, Toronto, ON, Canada, oylum.seker@utoronto.ca, Tınaz Ekim, Z. Caner Taskin

The Selective Graph Coloring Problem is a generalization of the standard graph coloring problem; given a graph with a partition of its vertex set into clusters, the objective is to choose exactly one vertex per cluster so that, among all possible selections, the number of colors needed to color the vertices in the selection is minimum. The problem is known to be NP-hard, and remains so in many special classes of graphs. We focus on a decomposition based exact solution framework for selective coloring in perfect graphs. Our experiments indicate that our approach significantly improves solution performance compared to an integer programming formulation and a state-of-the-art method from the literature.

3 - Simultaneous Optimization of Isocenter Locations and Sector Duration in Radiosurgery

Mucahit Cevik, Ryerson University, Toronto, ON, 53726, Canada, Dionne Aleman, Young Lee, Mark Ruschin

Stereotactic radiosurgery (SRS) is an effective technique to treat brain metastasis for which inverse planning methods are considered to be appropriate. We propose an integer programming model for the simultaneous sector duration and isocenter optimization (SDIO) problem in SRS to tractably incorporate treatment time to the planning process. We devise a Benders decomposition scheme to solve the SDIO problem to optimality. The performances of our approaches are assessed using anonymized data from previously treated cases, and obtained treatment plans are compared against each other and against the clinical plans.

4 - Combinatorial Benders Decompositions for Optimal Discretization Orders in Distance Geometry Problems

Merve Bodur, University of Toronto, 5 King's College Road, Toronto, ON, M5S 3G8, Canada, bodur@mie.utoronto.ca, Moira MacNeil

The Discretizable Distance Geometry Problem (DDGP) is a feasibility problem, based on determining total orders in graphs. Recently, measures of the quality of these orders have been proposed, transforming the DDGP from a feasibility problem to an optimality problem. We present two novel integer programming formulations for this optimality-based DDGP problem and develop Combinatorial Benders Decomposition algorithms for their solutions. Our computational experiments show these decompositions outperform existing integer programming formulations in the literature.

■ MB45

CC- Room 614

Fast and Provable Nonconvex Optimization Algorithms in Machine Learning

Sponsored: Optimization/Nonlinear Programming

Sponsored Session

Chair: Lam M Nguyen, IBM Research, Thomas J. Watson Research Center, Yorktown Heights, NY, 10562, United States

Co-Chair: Quoc Tran-Dinh, University of North Carolina at Chapel Hill, NC, United States

1 - Optimized SARAH for Finite-sum Smooth Non-convex Optimization

Lam M. Nguyen, IBM Research, Thomas J. Watson Research Center, Yorktown Heights, NY, 10562, United States, lamnguyen.mltd@ibm.com, Marten van Dijk, Dzung Phan, Phuong Ha Nguyen, Tsui-Wei Weng, Jayant Kalagnanam

We introduce NC-SARAH for non-convex optimization as a practical slightly modified version of the original SARAH algorithm that was developed for convex optimization. NC-SARAH is the first to achieve two crucial performance properties at the same time - allowing flexible minibatch sizes and large step sizes to achieve fast convergence in practice as verified by experiments. NC-SARAH has a close to optimal asymptotic convergence rate equal to existing prior variants of SARAH called SPIDER and SpiderBoost that either use an order of magnitude smaller step size or a fixed minibatch size.

2 - A Unified Variance-reduced Accelerated Gradient Method for Convex Optimization

Yi Zhou, IBM Almaden Research Center, 650 Harry Road, San Jose, CA, 95120, United States, yi.zhou@ibm.com, Guanghui Lan, Zhize Li

In this talk, we propose a novel randomized incremental gradient algorithm, namely, the variance-reduced accelerated gradient (Varag) algorithm, for solving finite-sum optimization problems whose objective function consists of the average of m smooth components. We demonstrate that Varag exhibits the unified optimal rates of convergence for solving both convex and strongly convex problems. In addition, we show that Varag exhibits an optimal linear rate of convergence for solving a wide class of weakly strongly convex problems, which only satisfy a certain error bound condition rather than strong convexity.

3 - Proxsarah an Efficient Algorithmic Framework for Stochastic Composite Nonconvex Optimization

Nhan Pham, University of North Carolina at Chapel Hill, Chapel Hill, NC, United States, nhanph@live.unc.edu, Lam M. Nguyen, Dzung Phan, Quoc Tran-Dinh

We propose a new stochastic first-order algorithmic framework to solve stochastic composite nonconvex optimization problems that covers both finite-sum and expectation settings. Our algorithms rely on the SARAH estimator and consist of two steps: a proximal gradient and an averaging step making them different from existing nonconvex proximal-type algorithms. The algorithms only require an average smoothness assumption of the nonconvex objective term and additional bounded variance assumption if applied to expectation problems. In all cases, we prove that our algorithms can achieve the best-known complexity bounds.

4 - On the Complexity of Approximating Wasserstein Barycenters

Cesar A. Uribe, MIT, Cambridge, MA, 02138, United States, cauribe@mit.edu, Alexey Kroshnin, Darina Dvinskikh, Pavel Dvurechensky, Alexander Gasnikov, Nazarii Tupitsa

We study the complexity of approximating the Wassertein barycenter of m discrete measures of size n using entropic regularization. The first approach is based on the Iterative Bregman Projections (IBP) algorithm for which our novel analysis gives a complexity bound proportional to mn2/ 2. Using an alternative accelerated-gradient-descent-based approach, we obtain a complexity proportional to mn2/ . We show that the regularization parameter in both approaches has to be proportional to , which causes instability when the desired accuracy is high. We propose a novel proximal-IBP algorithm, which can be seen as a proximal gradient method, which uses IBP on each iteration to make a proximal step.

■ MB46

CC- Room 615

Network Models and Routing Algorithms II

Sponsored: Transportation Science & Logistics/Intelligent Transportation Systems (ITS)

Sponsored Session

Chair: Pramesh Kumar, University of Minnesota, Minneapolis, MN, 55414, United States

1 - Anticipatory Network Path Assignment for Shared-ride Automated Vehicles Considering Proximity to Future Demands

Michael Hyland, University of California, Irvine, Irvine, CA, United States, hylandm@uci.edu

Shared-ride mobility services such as demand-responsive transit and UberPool/Lyft Line face operational challenges associated with dynamically planning vehicle routes under stochastic demands. To improve operational efficiency, this study proposes a bi-criteria network path assignment strategy for shared-ride vehicles that considers travel time and proximity of network paths to expected future demands. Compared with shortest path assignments, the bi-criteria approach should increase sharing opportunities and decrease operational costs. The study assumes fully-automated vehicles (AVs) that comply with non-shortest path directions.

2 - Critical Market Share of Fleet-optimal Vehicles for Reducing Traffic Congestion

Matthew Battifarano, Carnegie Mellon University, Pittsburgh, PA, United States, mbattifa@andrew.cmu.edu

Connected and autonomous technologies have radically altered mobility systems by enabling ad hoc vehicle fleets which may be easily coordinated by a central service. Previous studies have investigated how route choices of connected vehicles may be coordinated to regulate traffic flow. However, service providers may route their vehicles in a fleet optimal manner to benefit the fleet, neither optimized for the system nor for individuals. We investigate how ad hoc fleet routing impacts the network. We identify the minimum market penetration rate of these service fleets at which fleet optimal routing benefits the system and the minimum penetration rate at which traffic flow is system optimal.

3 - Finding Optimal Park-and-Ride Facility Locations in an Urban Network

Pramesh Kumar, University of Minnesota, Minneapolis, MN, 55414, United States, Alireza Khani

This study proposes a mixed integer nonlinear programming (MINLP) problem to find the optimal location of park-and-ride facilities in an urban network. The objective is to minimize the total system travel time while satisfying stochastic user equilibrium.

4 - A Bi-Level Approach for Control of Large-Scale Urban Network using Macroscopic Fundamental Diagram

Seiran Heshammi, University of Calgary, Calgary, AB, Canada, Nadia Moshahedi, Lina Kattan

In this work, a large-scale urban network control problem under user equilibrium is investigated. The modeling approach adopted is Macroscopic Fundamental Diagram, dividing urban network into roughly homogeneous regions with a unimodal low-scatter relationship between network accumulation and outflow. To be able to globally control the large-scale urban network and reduce computational burden, both control and traffic assignment are done at regional level. The problem is modeled in the form of bi-level programming and solved using iterative optimization approach.

■ MB47

CC- Room 616

Joint session TSL AIR/ AAS/Practice Curated: Machine Learning Models for Airline Scheduling and ATM

Sponsored: Transportation Science & Logistics/Air

Sponsored Session

Chair: Lavanya Marla

Co-Chair: Ankur Mani, University of Minnesota, Minneapolis, MN, 63108-2432, United States

1 - Collaborative Routing and Sensing in the National Airspace

Jing Gao, University of Minnesota, Minneapolis, MN, 55114, United States, gao00030@umn.edu

The lack of availability of real-time information about changing weather makes the reconfiguration of airspace's and airline's network become difficult. To overcome this shortcoming, our project developed an integrated model-based and data-driven approach to design the detours deviating from normally optimal routes by utilizing in-use aircrafts as sensors to collect data. It can be shown our approach can enable true dynamic routing of aircrafts, minimize future delays and disruptions.

2 - Flight Plans Vs. Flight Policies: A Pilot'S Perspective

Ashish Kapoor, Microsoft, Redmond, WA, United States, akapoor@microsoft.com

Aerial Autonomy promise to increase efficiency, reduce cost and most importantly take on tasks that are too difficult for humans. The current flight missions, often with a human pilot in the loop, are plans based - where the sequence of actions or the path is (mostly) known a priori. Many recent advances in autonomy are resulting in systems that are policy based, where the set of actions are stochastic, non-deterministic and often difficult to predict. I'll discuss various advantages and disadvantages of along the continuum between flight plans and flight policies. I'll also put forward a pilot's perspective on various case studies which will range from small UAVs to real-world commercial aircraft.

3 - Integrated Aircraft and Crew Recovery Using Machine Learning and Optimization

Ahmet Esat Hizir, Massachusetts Institute of Technology, Cambridge, MA, United States, aehizir@mit.edu, Cynthia Barnhart, Vikrant Vaze

Due to the irregular nature of flight operations, airlines need to take a range of actions to recover their aircraft/crew schedules and passenger itineraries. In practice, this process has a sequential structure in which aircraft recovery is followed by crew and passenger recovery. While recovery problems are smaller in scope than their planning counterparts, limited time frames prevent airlines from using a full-scale optimization approach. This study proposes a set of new and practical ideas that combine machine learning and optimization tools to find near-optimal solutions for the integrated aircraft and crew recovery problem within limited time frames.

■ MB48

CC- Room 617

Innovative Last-Mile Delivery Concepts

Sponsored: Transportation Science & Logistics/Freight Transportation & Logistics

Sponsored Session

Chair: Tino Henke, Otto-von-Guericke University Magdeburg, Magdeburg, 39106, Germany

1 - When Microseconds Add Up: on the Real-Time Performance of Dynamic Time Slot Management

Niels Agatz, Rotterdam School of Management, Erasmus University, Rotterdam School of Management, Burg. Oudlaan 50, Rotterdam, Netherlands, nagatz@rsm.nl, Thomas Visser, Remy Spliet

To facilitate attended home delivery, e-grocers typically offer customers a menu of narrow delivery time slots to choose from. When the fulfillment capacity is scarce, the e-grocer should determine which time slots to offer to specific customers given the already accepted customer orders. Dynamically constructing the set of delivery time slots for a specific customer is often referred to as dynamic time slot management. In this contribution, we present several synchronization issues that occur due to the simultaneous interaction of different customers with the system and introduce procedures to deal with these issues.

2 - Package Deliveries with Autonomous Robots

Iurii Bakach, University of Iowa, Iowa City, IA, 52240, United States, iurii-bakach@uiowa.edu, Ann Melissa Campbell, Jan Fabian Ehmke

Autonomous robots can help making last-mile deliveries more efficient and customer friendly. We examine the use of robots to deliver individual packages in urban last-mile delivery. We look at the number of robots and robot hubs required along with time of completion as compared with traditional truck delivery models. We examine different assumptions on the speed of travel, geography, working hours and customer time window preferences to understand where autonomous robots are particularly valuable.

3 - An Urban Freight Share-a-Trip Delivery Problem

Dingtong Yang, University of California, Irvine, CA, United States, dingtony@uci.edu, Michael Hyland, R. .Jayakrishnan, Chenying Qin

Large numbers of drivers commute daily with empty space in their personal vehicles, which can be leveraged for freight delivery. This paper presents an urban freight delivery system where packages share space in light-duty personal vehicles as well as commercial trucks. The problem is formulated as a quadratic mixed integer program based on the m-VRP. The formulation minimizes total delivery cost and considers time window and capacity constraints. Preliminary results show a 55% reduction in VMT and a 60% decrease in total delivery costs compared to truck-only commercial delivery services.

4 - Mobile Collection Points in Crowdshipping

Alp Arslan, Singapore Management University, Pannekoekstraat 58C, Singapore, 3011LJ, Singapore, amuzaffera@smu.edu.sg, Shih-Fen Cheng

In this study, we introduce mobile collection points in last-mile delivery systems that rely on crowdsourced delivery capacity. We study the benefits of these points, i.e large size trucks, in a setting, in which they bring batches of parcels to the vicinity of crowd drivers' preferred delivery areas. We develop an optimization algorithm to solve a large scale the home delivery problem by integrating these collection points. In the numerical experiments, we show that one can increase the number of customers served by using mobile points.

5 - A Matheuristic for Planning Last-Mile Deliveries with Mobile Pick-up Stations

Tino Henke, Otto-von-Guericke University, Universitaetsplatz 2, Magdeburg, 39106, Germany, Jan Fabian Ehmke

Mobile pick-up stations have recently been proposed as an innovative concept for efficient last-mile deliveries. Such stations can be moved flexibly to temporary locations from which customers can then conveniently collect their parcels. We regard one particular problem in this context, which combines vehicle routing and location planning. For solving this problem, a matheuristic approach has been developed and tested by means of numerical experiments. The main findings as well as managerial insights on using mobile pick-up stations will be presented.

■ MB49

CC- Room 618

Optimizing Learning Toward Mobility-as-a-Service Networks

Sponsored: Transportation Science & Logistics/Urban Transportation

Sponsored Session

Chair: Joseph Y J Chow, New York University, New York, NY, 10012, United States

1 - An Integrated Learning & Progessive Hedging Matheuristic for Stochastic Network Design

Teodor Gabriel Crainic, Universite du Quebec a Montreal, School of Management, Department of Management & Technology, Montreal, QC, H3C 3P8, Canada, TeodorGabriel.Crainic@cirrelt.net, Walter Rei, Fatemeh Sarayloo

The matheuristic decomposes the stochastic network design problem into multi-scenario subproblems according to progressive-hedging principles. A learning-based procedure, combining heuristic-search techniques with mathematical programming, is used to address the subproblems and to acquire knowledge on promising design structures. This knowledge is then used to update the reference point and guide the overall search. Extensive computational experiments illustrate the efficiency of the proposed matheuristic in obtaining high-quality solutions with limited computational effort, particularly when addressing instances with many scenarios.

2 - Tripod: An Online Choice-Based Recommender System

Mazen Danaf, PhD Candidate, Massachusetts Institute of Technology, Cambridge, MA, United States, mdanaf@mit.edu, Yifei Xie, Carlos Lima de Azevedo, Bilge Atasoy, Moshe Emanuel Ben-Akiva

This paper presents the choice-based recommender system for Tripod, an app-based trip planner offering a personalized menu with real-time predicted information and optimized incentives. Users receive incentives in the form of tokens that can then be redeemed in a market place for goods and services offered by third party providers. Personalized recommendations are generated for each trip once a Tripod menu is requested. The online estimation framework proposed by Danaf et al. (2019) is used to update individual preferences after each choice. A large number of users is simulated to demonstrate scalability and show how the average hit-rate increases over time as we learn individual preferences.

3 - Bayesian Optimization for Stochastic Traffic Network Planning Problems

Zhen Tan, Nottingham University Business School (China), Ningbo, China

We propose a Bayesian learning method for solving stochastic traffic network optimization problems. By incorporating structured beliefs on the performance of each candidate solution, this method allows relatively cheap implementation and prevents evaluation of a large number of solutions. As an illustration, we apply the method to a public bicycle planning problem in which we have to decide the location and the size of each of the bicycle stations with the goal of minimizing the expected travel cost and construction cost under uncertain demand.

4 - Sequential Line Planning Problem with Integrated Learning for Emerging Mobility Routes

Gyugeun Yoon, New York University, Brooklyn, NY, 11201, United States, ggyoon@nyu.edu, Joseph Y.J. Chow

With limited information about travel patterns, operating a flexible transit system is difficult to achieve. This study proposes a novel sequential line planning algorithm incorporating the learning of prevailing mobility service demand to overcome the uncertainty of demand. From a generated feasible route set, the algorithm sequentially deploys individual routes and expands the system to obtain the optimal route set. Decisions made to determine which route to introduce is based on the ridership information learned by experimental vehicle operations. It will be able to assist the decision making to set the order in which route should be launched and keeping a limited resource budget.

■ MB50

CC- Room 619

Recent Trends in Facility Logistics

Sponsored: Transportation Science & Logistics/Facility Logistics

Sponsored Session

Chair: Sadan Kulturel-Konak, Penn State Berks, Reading, PA, 19610, United States

1 - The Forward-reserve Design Problem in Order Picking Warehouses with High Volume of Small Parts

Alice E. Smith, Auburn University, Dept of Industrial/Sys Engineering, Auburn, AL, 36849, United States, smithae@auburn.edu, Eliana Pena Tibaduiza, Mario Velez Gallego

Some order picking warehouses have improved their operations by designating a forward area. This area is a small zone that concentrates selected Stock Keeping Units (SKUs), thereby reducing travel times for order pickers. These SKUs must be replenished from the reserve area, incurring a replenishment labor cost. The forward-reserve design problem includes the definition of the size of the forward area, the SKUs to be stored in it, and the space allocate to each SKU. The aim of this research is to relax the common assumption that the distance traveled by pickers within the forward area is negligible.

2 - Advances in QAP and M-facility Placement

Rakesh Nagi, University of Illinois at Urbana, Urbana, IL, 61801, United States, nagi@illinois.edu

Finite-size facility location is an interesting confluence of facility layout and location analysis. We will cover the M-Finite size facility location problem where the continuous placement on a plane is transformed to a set of discrete candidate points. We will also cover recent advances in solving the Quadratic Assignment Problem, using RTL2 formulation and GPU computing.

3 - Game Theoretic Genetic Algorithm to Solve the Facility Location Problem

Sadan Kulturel-Konak, Penn State Berks, Reading, PA, 19610, United States, sadan@psu.edu, Abdullah Konak, Lawrence V. Snyder

We demonstrate an application of Game-Theoretic Genetic Algorithm (GTGA) to the Competitive Maximal Covering Location Problem, which is typically modeled as a two-player Stackelberg game such that first one player and then the other locate a fixed number of facilities to capture a maximum amount of revenue in a region. In contrast, the present work considers multiple players as well as both sequential and simultaneous games. Computational experiments show that the GTGA can converge to Stackelberg and Nash equilibria as well as outperform some existing approaches.

■ MB51

CC- Room 620

Joint Session AAS/TSL Air: AAS Applications Section Distinguished Speaker Session

Sponsored: Aviation Applications

Sponsored Session

Chair: Chiwei Yan, MIT

1 - Online Gradient-descent Methods for Computing Capacity Allocation and Bid Prices with Stochastic Demand

Shashi Mittal, Director, Research Science, Amazon, Seattle, WA, United States

Accurately controlling the package and passenger flow in an airline network is central to the financial health of an airline carrier. We illustrate that using Online Gradient Descent algorithm, which is inspired from similar algorithms used for solving optimization problems arising in Machine Learning literature, performs better than traditional methods. Our computational experiments show a reduction in the overall run-time for computing the optimal bid prices by 43% compared to traditional sub-gradient algorithms. Joint work with Pornpawee Bumpensanti, Shashi Mittal, Tim Jacobs and Tyler White.

■ MB52

CC- Skagit 1

Computational Methods in RM

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Gustavo J. Vulcano, Universidad Torcuato di Tella, Buenos Aires, 1428, Argentina

1 - Revenue-utility Trade off in Assortment Optimization under the Multinomial Logit Model with Totally Unimodular Constraints

Mika Sumida, Cornell Tech, New York, NY, 10128, United States, ms3268@cornell.edu, James Mario Davis, Guillermo Gallego, Paat Rusmevichientong, Huseyin Topaloglu

We consider an assortment optimization problem under a multinomial logit choice model with a social welfare objective that is the weighted sum of the revenue from the assortment and the expected maximum utility obtained by each customer. Our formulation allows for arbitrary totally unimodular constraints on the offered sets and generalizes existing formulations in the literature. We characterize the structural property of an optimal solution and prove that revenue-maximizing assortments, for appropriately adjusted revenues, are also socially optimal. We develop an efficient algorithm that computes the optimal solution based on parametric linear programming.

2 - Heteroscedasticity in Discrete Choice: An Empirical Test of Exponomial and Logit Models on Transportation Data

Rajesh Paleti, Pennsylvania State University, University Park, PA, United States, Aydin Alptekinoglu

An attractive feature of the heteroscedastic exponomial choice (HEC) model is its closed-form probability expression. In this study, the empirical applicability of HEC model is demonstrated in two choice contexts within the transportation domain - new vehicle purchase decisions and airline itinerary choices. The model fit as well as behavioral implications of the HEC model are compared against the heteroscedastic variant of the MNL model, called the heteroscedastic extreme value (HEV) model, which does not have a closed-form choice probability expression.

3 - Customer Loyalty in Ride-Hailing: Empirical Evidence

Dmitry Mitrofanov, New York University, New York, NY, 10012, United States, Maxime Cohen, Srikanth Jagabathula

Are customers loyal to a specific ride-hailing platform or they see this service as a commodity? Using a large panel dataset on ride-hailing transactions, we investigate to what extent customers are loyal. Our dataset offers a unique opportunity to study this question as we observe the choices for both Uber and Lyft. We first propose a way to overcome the issue of missing data on waiting times and competitor prices. We then estimate several reduced-form and choice models to examine customer loyalty and switching patterns. We find that even after controlling for prices and waiting times, customers are loyal to the most frequently used platform.

4 - Assortment Optimization Over Dense Universe is Easy

Goutam Kumar, Columbia University, New York, NY, United States, kg2621@columbia.edu, Vineet Goyal, Henry Lam

We investigate an alternate, continuous-space approximation to assortment optimization under mixed MNL model. We consider the case where product space is large. When features are densely populated (in stochastic or deterministic sense), we show that, among any possible assortment schemes represented by open sets containing assorted features, there exists a nested-by-revenue policy that is optimal. This characterization holds regardless of mixture distribution (it can be discrete or continuous) and dimension of feature space. We utilize tools from empirical process literature and derive an error bound between expected revenue evaluated by nested-by-revenue policy and global best policy.

■ MB53

CC- Skagit 2

Interface between Operations and Marketing

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Simone Marinesi, Wharton, Philadelphia, PA, 19103, United States

Co-Chair: Ruslan Momot, HEC Paris, HEC Paris, Jouy-en-Josas, 78350, France

1 - Managing Outside Funds in a Crowdfunding Campaign

Behrooz Pourghannad, University of Minnesota, Minneapolis, MN, 55901, United States, behrooz@umn.edu, Guangwen Kong, Laurens G. Debo

We study how an entrepreneur's use of social network infuses the crowdfunding campaign. We investigate how the investment from family and friends may impact the amount of investment that the entrepreneur could seek and how reciprocities can change the information flow.

2 - Incentive Design for Operations-marketing Multitasking

Christopher Ryan, University of British Columbia, 5807 S. Woodlawn Ave, Vancouver, BC, 60637, Canada, Tinglong Dai, Rongzhu Ke

A firm hires a store manager to make operational and marketing efforts. The outputs — demand and capacity — face demand censoring. We show the optimal compensation plan is a base salary with bonus paid when (i) a minimum level of inventory is sold out, or (ii) sales meets an inventory-dependent target.

3 - Should I Pay with Money or Redeem Points for this Purchase? How Exchange Rate Stability Influence Loyalty Point Redemption

So Yeon Chun, INSEAD, McDonough School of Business, 37th and O. Streets NW, Fontainebleau, 20057, France, soyeon.chun@insead.edu, Rebecca Hamilton

In many loyalty programs, customers earn points for their purchases, which they can later exchange for additional products and services. In this work, we examine how the program design characteristics of the exchange rate between money and points affect consumers' redemption choices. We first propose a conceptual model of the consumer's choice to redeem points then we analyze both secondary data from an airline loyalty program and primary data from experimental studies. We propose an underlying mechanism that can explain systematic behavior biases and discuss managerial implications.

4 - Created Unequal: Bundling with Crowdsourced Products

Lu Wang, Shanghai University of Finance and Economics, #100 Wudong Road, Shanghai, China, wang.lu@mail.shufe.edu.cn, Ming Hu

As consumer buying habits are trending toward more simple and hassle-free experiences, more and more companies are jumping into the innovative business model of subscription services. Subscription providers such as Spotify, Netflix and OneGo (an all-you-can-fly subscription service provider) crowdsource products/services from many vendors and bundle them for the price of one. The collected subscription fees for the bundle then are allocated according to the realized contributions by each crowdsourced product. However, this allocation scheme may create incentive incompatibility for vendors. We examine the incentive compatibility of different parties under various bundling strategies.

■ MB54

CC- Skagit 3

Networks, Mechanism Design, and New Markets – I

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Ozan Candogan, University of Chicago, Chicago, IL, 27708, United States

1 - Optimal Subscription Planning of Digital Goods

Ali Makhdoumi, Duke University, W315, 100 Fuqua Drive, Durham, NC, 27705, United States, Azarakhsh Malekian, Saeed Alaei

We consider the problem of a service provider selling digital goods such as movies to customers. The service provider (platform) chooses a subscription planning which specifies the set of movies to include in the subscription set, the subscription fee, and the price of individual movies. We find the optimal characterization of these choices.

2 - Incentives to Crowdsource Information in Informal Supply Chains

Joann de Zegher, MIT Sloan, Cambridge, MA, 02142, United States, jfz@mit.edu, Irene Yuan Lo

Over 60% of global employment operates in informal work environments, where decisions often rely on limited information from informal networks. In informal supply chains, network members also compete, which further disincentivizes sharing valuable information. We design incentive-compatible information-sharing mechanisms for such informal supply chains. To incentivize sharing, we select information disclosure policies that depend on information shared by members. We characterize optimal policies and show that sharing emerges as a SPNE that improves welfare of all members. Our model is informed by an information-sharing platform in informal palm oil supply chains in rural Indonesia.

3 - A Tale of Timescales: Surge Pricing and Dynamic Matching in Ride-hailing Networks

Zhe Liu, Columbia University, New York, NY, United States, ZLiu18@gsb.columbia.edu, Philipp Afeche, Costis Maglaras

We study a ride-hailing platform that matches price and delay sensitive riders with strategic drivers. Our model jointly considers surge pricing and dynamic spatial matching when the platform responds to an uncertain demand shock at a hotspot. Our results show the interplay between important timescales, e.g., rider patience, shock duration, and drivers' travel delay to the hotspot, and their impact on system performance.

4 - Fake Content Propagation in Social Networks and Factchecking Policies

Gizem Yilmaz, The University of Chicago, Chicago, IL, 60615, United States, Ozan Candogan, Varun Gupta

Social media platforms have introduced fact-checking programs to combat misinformation in online social networks. However, the limited capacity of the fact-checking resource does not allow to review all content in a timely manner. In this paper, we develop policies that prioritize different pieces of content for fact-checking to reduce the spread of erroneous content in the underlying social network. Our approach allows us to develop online matching algorithms with provable performance guarantees in settings where rewards decay over time, provided that they exhibit a 'decreasing differences' property.

■ MB55

CC- Skagit 4

Revenue Management and Marketplace Analytics I

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Kalyan Talluri, Imperial College Business School, London, SW7 2AZ, United Kingdom

1 - On the Power of Bounded Memory Peak End Demand Models

Tamar Cohen, MIT, Somerville, MA, 02144, United States, tcohen@mit.edu, Georgia Perakis, Kiran Panchamgam

We consider the problem of promotion planning for a single product, with bounded memory peak end demand. We show that when using this demand model, the optimal promotion policy will require at most two price levels. We then show that with a finite planning time horizon and a limit on the number of deviations from full price, we can find the structure of the optimal pricing policy. We characterize when the optimal policy is cyclic, as well as when a cyclic policy is not optimal. Finally, we show that even in the cases that we misclassify the demand model, and the true demand model does not fit the bounded memory peak end model, the estimation error is small. We provide an analytical bound on this estimation error.

2 - Dynamic Pricing in Ride-Hailing Marketplaces

Hamid Nazerzadeh, USC Marshall / Uber Technologies, Los Angeles, CA, United States, nazerzad@usc.edu

Ride-hailing marketplaces match millions of riders and drivers every day. One of the key features of Uber's marketplace is dynamic pricing, so called surge, that balances the demand for trips and the supply of available cars. The surge pricing also motivates drivers to relocate to parts of the city with higher demand. In this talk, I'll discuss the design and implementation of Uber's new driver surge mechanism.

3 - Threshold Utility Model with Applications to Retailing and Discrete Choice Models

Guillermo Gallego, Hong Kong University of Science and Technology, Hong Kong, 852, Hong Kong, ggallego@ust.hk, Ruxian Wang

We consider a threshold utility model (TUM) where consumers buy all products whose net utility exceeds a product-specific threshold. The consumer selects the thresholds to maximize the expected surplus subject to a bound on the expected number of selected products. We analyze properties of the TUM and consider both pricing and assortment optimization problems. We obtain optimal pricing policies and show that the assortment problem is NP-hard. An efficient approximation is developed with tight bounds. The TUM can also be used as a consideration set model. We establish tight bounds on the expected surplus of this consideration set model relative to that obtained by observing all products.

4 - Overbooking with Endogenous Demand

Rowena J. Gan, Wharton School of Business, University of Pennsylvania, Philadelphia, PA, 19103, United States, ganj@wharton.upenn.edu, Noah Gans, Gerry Tsoukalas

Using airlines as a backdrop, we study optimal overbooking policies with endogenous customer demand, when customers internalize their expected cost of being bumped. We first consider the traditional setting in which compensation for bumped passengers is fixed. We then extend our analysis to the case of auction-based compensation schemes and demonstrate that these generally outperform fixed compensation schemes. Numerical experiments that gauge magnitudes suggest that fixed-compensation policies that account for demand endogeneity can significantly outperform those that do not and that auction-based policies bring smaller but still significant additional gains.

■ MB56

CC- Skagit 5

Urban Applications of Revenue Management

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Claudius Steinhardt

Co-Chair: Arne Strauss

Co-Chair: Catherine Cleophas, Cau Kiel, Kiel, 24114, Germany

1 - Dynamic Pricing of Nested Time Windows in Attended Home Delivery

Sebastian Spindler, Bundeswehr University Munich, Munich, Germany, sebastian.spindler@unibw.de, Claudius Steinhardt

A common practice in attended home delivery is that customers can choose from differently priced time windows in which delivery will take place. The offered time windows are often nested in the sense that customers can either choose to be delivered in one of several narrow time windows, or in a wider window comprising several adjacent narrow windows, which then is usually cheaper. In this research, we address this setting and present an approach of dynamically determining prices, taking the suppliers additional operational flexibility arising from nested time windows into account.

2 - Dynamically Managing Delivery Time Slots and Vehicle Routing Across Multiple Days

Arne K. Strauss, University of Warwick, Coventry, United Kingdom, Arne.Strauss@wbs.ac.uk, Nalan Gulpinar, Yijun Zheng

Current research on demand management for attended home delivery typically considers deliveries for a single day only due to the difficulties in dynamically optimizing slot availabilities for many slot options across multiple days. However, in practice customers do typically choose a slot across multiple delivery days and hence we investigate how the modeling assumption that a customer is only interested in a single day affects overall profits. We empirically show that using more accurate choice models can increase total profitability when delivery capacity is tight. However, somewhat counterintuitively, this improvement is small and if capacity is ample, simple MNL models may in fact be better.

3 - Price List Optimization for Free-Floating Car Sharing Systems

Matthias Soppert, Universität der Bundeswehr München, Werner-Heisenberg-Weg 39, Building 36, Neubiberg, 85577, Germany, matthias.soppert@unibw.de, Claudius Steinhardt

Free-floating car sharing providers experience a strong growth of users but often struggle in generating a profitable fleet utilization. We study a car sharing provider's tactical problem of finding a profit-maximizing price list that differentiates minute prices locally and temporally. The car sharing system is represented as a network flow model in which the area of operation is discretized into zones and car rentals between different zones are modeled by flows within the network. In particular, we focus on the special characteristics of a free-floating system and its appropriate modeling and discuss solution approaches as well as numerical results for practice-relevant problem sizes.

4 - Surge Pricing in Shared Mobility Systems

Dennis H. Proksch, Bundeswehr University Munich, Neubiberg, Germany, Claudius Steinhardt

Research about shared mobility systems (SMS) has been mainly focused on either improving the service quality - often assuming public subsidies - or introducing vehicle relocation. This research focuses on increasing profit margins sustainably by dynamically adjusting the rent per minute. To compute efficient rents we present a mixed integer program which defines the system model according to approximate dynamic programming. As a direct lookahead only yields minor improvements, we set on to exploit the model structure and derive simple pricing policies, whose parameters we estimate via stochastic search. Our results suggest that SMS might increase their net revenue by up to ten percent.

5 - Anticipative Dynamic Slotting for Attended Home Deliveries

Catherine Cleophas, CAU Kiel, Kiel, 24118, Germany, cleophas@bwl.uni-kiel.de, Magdalena K. Lang, Jan Fabian Ehmke

To enable short time slots and punctual arrivals, efficient planning has become crucial factor in ensuring the profitability of attended deliveries. Planners need to anticipate the effect of promising to deliver orders in specific time slots on the further capacity for deliveries. To find reasonable solutions with limited computational effort, we present dynamic slotting approaches that consider anticipative routing information and approximate the opportunity cost of accepting orders based on a value function model. The results inform the dynamic time slot allocation per arriving order request. We present computational results on synthetic and empirical demand scenarios.

6 - Flexibility-based Time Window Pricing for Attended Home Deliveries

Jan Fabian Ehmke, Otto-von-Guericke University, Magdeburg, 39106, Germany, jan.ehmke@ovgu.de, Charlotte Köhler, Ann Melissa Campbell, Catherine Cleophas

In the challenging environment of attended home deliveries, pricing of time windows can play a crucial role to ensure the profitability and service quality of online retailers. Our goal is to nudge customers to choose time windows that do not overly restrict the flexibility of route plans. To this end, we present dynamic pricing policies that vary delivery fees according to the flexibility of the evolving route plans. We examine in which situations our policies can induce more revenue for the retailer and/or improve customer service. We compare these policies to simpler static pricing policies that reflect common business practice.

■ MB57

CC- Yakima 1

Data Driven Disaster Resilience

Sponsored: Public Sector OR

Sponsored Session

Chair: Benjamin Rachunok, Purdue University, West Lafayette, IN, 47906, United States

1 - Twitter and Disasters, Learning Resilience from Social Media

Benjamin Rachunok, Purdue University, West Lafayette, IN, 47906, United States, brachuno@purdue.edu, Jackson Benentt, Roshanak Nateghi

Understanding the resilience of a community facing a crisis event is critical to improving its adaptive capacity. Community resilience has been conceptualized as a function of the resilience of components of a community such as ecological, infrastructure, economic, and social systems etc. In this talk I introduce the concept of a resilience fingerprint and propose a multi-dimensional method for analyzing components of community resilience by leveraging existing definitions of community resilience with data from the social network Twitter. Results are presented showing how natural disasters and crisis events have distinguishing signatures which are apparent in Twitter data.

2 - Measuring and Modeling Information Flow Online

James Bagrow, University of Vermont, Burlington, VT, United States, James.Bagrow@uvm.edu

Society now depends on the flow of information over online social networks, especially during disasters and extreme events, and popular social platforms now generate significant volumes of behavioral and communication data. In this talk, I will review some of our prior studies using social media to understand disaster situations. This work has led us to study information flow by applying tools from information theory to estimate the information content of posts from Twitter users and to what extent information flows between users. Temporal and social effects are visible in the information flow, and these estimates provide a fundamental bound on the predictive accuracy achievable with these data.

3 - Sensemaking Around Visual Hurricane Risk Messaging

Melissa Bica, PhD Candidate, University of Colorado Boulder, Boulder, CO, United States, melissa.bica@colorado.edu

My research investigates the difficulty in conveying risk and uncertainty for hurricanes. Hurricane risks are commonly communicated through visualizations, some of which are issued as formal products by organizations like NOAA. However, little is known about the effectiveness of such risk products in supporting people's risk assessment and decision-making. To address this, I use a mixed-methods approach to investigate aspects of individual and collective human interaction with hurricane risk imagery during real hurricane events, using Twitter as the platform for capturing this activity. This work offers contributions regarding design, methodology, and policy.

4 - Analytics-driven Inspection Strategies for Post-storm Infrastructure Damage Assessment

Andrew Lee, Massachusetts Institute of Technology, Cambridge, MA, United States, aclee@mit.edu, Mathieu Dahan, Jeremy Justice, Cynthia Barnhart, Saurabh Amin

Delayed identification of storm-induced damages across coastal infrastructures often contributes to high economic and societal costs. To reduce the impact of damage, we address a critical knowledge gap by developing an analytics-driven approach for inspection of large-scale infrastructure networks in the aftermath of storm events. Our approach integrates flexible diagnostic information from fixed and aerial sensors to design inspection crew routing strategies for rapid post-storm damage identification. Using drainage network inspection data following 2017's Hurricane Harvey, we show that prioritizing inspection based on damage indicators leads to significant cost and time-savings.

5 - Towards the Discovery of Emergent Behaviors for Transportation Planning

Cathy Wu, MIT, Cambridge, MA, United States

How will self-driving cars change urban mobility? This talk focuses on the systems and optimization methods neccessary to gain insight into this question by enabling the discovery of their emergent behaviors in the complex transportation dynamical system. The optimization methods, empirical findings, and the systems that power them demonstrate how small changes in vehicles, sensors, and infrastructure can be harnessed for insights that inform transportation planning, potentially affecting everyday use, disaster planning, as well as the design of future mixed autonomy systems.

■ MB58

CC- Yakima 2

Joint Session Policy and Government/PSOR: Cybersecurity & Homeland Security Policy

Emerging Topic: Policy & Government

Emerging Topic Session

Chair: Laura Albert, University of Wisconsin, Madison, WI, United States

1 - A Network Interdiction Model for Delaying Adversarial Attacks and Protecting Cyber-infrastructure

Laura Albert, University of Wisconsin-Madison, Industrial & Systems Engineering, Madison, WI, 53706, United States, laura@engr.wisc.edu, Kaiyue Zheng

We present Stackelberg game models that formulate the interaction between a defender and multiple attackers with application to cyber-infrastructure protection. Network interdiction models are formulated that prioritize cost-effective security mitigations to maximally delay adversarial attacks. Attacks originate from multiple adversaries, each of whom aims to find a "critical path" through the attack surface to complete the attack as soon as possible. Decision makers can deploy mitigations to delay attack exploits, however, mitigation effectiveness is uncertain.

2 - Optimal Off-Line Experimentation for Designing Cyber Security CTF Red/Blue Team Games

Theodore T. Allen, PhD, Ohio State University, Columbus, OH, 43210-1271, United States, allen.515@osu.edu

We study a new class of experimental planning problems in which one has uncertain game parameters and the ability experiment off-line, i.e., with no cost in actual (on-line) games but with testing costs. The off-line experimentation could use a simulation model of a system with inputs from two or more players. It could also be a pre-experiment before the commission of significant resources. Through novel analysis, we obtain results about optimal efficient off-line experimentation and the sufficiency of experimentation for characterizing the Nash equilibria. Finally, we illustrate the application of the methods to a cyber security Capture The Flag (CTF) red team/blue team game problem.

3 - Estimating Wireless Mesh Network Vulnerability: A Search for the "Best" Interference Model

Tanveer Bhuiyan, PhD Student, University of Tennessee, Knoxville, TN, United States, tbhuiyan@vols.utk.edu, Hugh Medal

This paper studies the problem of placing a set of jammers in 3-D space to minimize the throughput of a wireless communication network. The main goal of this paper is to study the effects of jamming under the following models of interference: physical, capture, protocol, and interference range. This paper presents a mixed-integer programming model and branch-and-cut procedure for the jammer location problem under several models of interference. We implement multiple valid inequalities including clique and odd-cycle inequalities to speed-up the branch-and-cut algorithm. Numerical experiments demonstrate the effect of different interference models on runtime and solution tractability.

4 - Multifirm Models of Cybersecurity Investment Competition vs. Cooperation and Network Vulnerability

Shivani G. Shukla, University of San Francisco, San Francisco, CA, 94117, United States, shivani.shukla@usfca.edu, Anna Nagurney

We develop and compare three models for cybersecurity investment in competitive and cooperative situations to safeguard against cyber threats. A Nash equilibrium model of noncooperation in terms of cybersecurity levels of the firms involved is introduced. The equilibrium of this model then acts as the disagreement point over which bargaining takes place in the second model, which yields a cooperative solution that guarantees their expected utilities are no lower than those achieved under noncooperation. Nash bargaining theory is utilized to argue for information sharing and to quantify its monetary and security benefits in terms of reduction in network vulnerability to cyberattacks.

■ MB58a

CC- Chelan 1

11:00-11:45 JMP, a Division of SAS
11:45-12:30 AIMMS

Vendor Tutorial

1 - For the Love of Crocs: Text Mining Product Reviews with JMP Pro

Ruth Hummel, JMP, a Division of SAS, Cary, NC, 27513, United States

JMP Pro from SAS provides leading edge descriptive and predictive analytics capabilities including text mining which will be demonstrated in this session. Are you wondering what you can do with your unstructured text data? Or are you just very interested in figuring out why people love Crocs shoes so passionately? In this talk we will explore the world of text-mining, using product reviews of Crocs shoes. We will look at summary info and word clouds, we will build features like keyword indicators and clusters (both for the terms that tend to co-occur and for the people who seem to say similar things). We will then use these document term analytics in modern variable selection methods to incorporate information from the unstructured text back into structured data analytics problems.

2 - Accelerating Optimization Model Development with AIMMS

Mohan Chiriki, AIMMS, Bellevue, WA, United States

Looking to accelerate optimization model creation? Whether you are in academia or business, AIMMS allows you to easily combine the power of Operations Research and Data Analytics in a single platform. Along with an integrated user interface, AIMMS makes model creation, visual representations and scenario analysis a breeze. In this tutorial, we will demo some of the platform's features, including: • An intuitive modeling interface o See how simple it is to model variables and constraints from your mathematical formulation o See how our built-in diagnostic tool allows you to analyze a model and helps improve efficiency • Discover ready to use extensions like Collaborative Data Management (CDM) and how they help you bring an app to life • Easy data import/export • See our Excel and database data exchange in action • Leverage the power of R • Number crunching with R libraries through IMMS R-link to add statistical and other Data Science capabilities to your model • Fun AIMMS integrations • Extract Photos Using the Flickr API • Retrieve Geographic Data with the Google Maps API Like what you see? You can continue exploring with our free academic licenses and 30-day trial license for industry users.

■ MB59

CC- Chelan 2

QSR Data Challenge

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Linkan Bian, Mississippi State University, MS, 39762, United States

Co-Chair: Weihong Guo, Rutgers, The State University of New Jersey, Piscataway, NJ, 08854, United States

1 - QSR Data Challenge

Linkan Bian, Mississippi State University, Industrial and Systems Engineering Department, Mississippi State University, MS, 39762, United States

This session is a data competition session. The presenters will be selected based on a peer review process. The outcomes will not be announced until Sep 2019.

■ MB59a

CC- Chelan 3

Finance I

Contributed Session

Chair: Thunyarat Bam Amornpetchkul, NIDA Business School, 10240, Thailand

1 - How Can SMEs Obtain Supply Chain Financing? An Empirical Research of Information Transmission

Mengyin Li, Renmin University of China, Beijing, China, limengyin@ruc.edu.cn, Song Hua

Unlike traditional bank lending, supply chain financing relies on specific information generated by the supply chain networks and operation process. We consider supply chain financing decision making based on the specific information, including upstream and downstream enterprises, operation efficiency, and other information.

2 - Optimal Dynamic Pricing of Products with Decreasing Quality under Stochastic Preferences

Arik Sadeh, HIT Holon Institute of Technology, Holon, Israel, sadeh@hit.ac.il, Idan Babay, Cristina Feniser

Consider a single product with varying levels of quality. The total amount of products by their quality has to be sold in predetermined units of time steps. The expression of an agent's choice is made by using a stochastic preference utility. Agents strive to maximize their preference utility from the product and its quality. They have a defined sensitivity random parameter for the quality of the product as well as its cost. This stochastic dynamic pricing problem is solved in a dynamic programming framework. Having solved the dynamic pricing scheme, decision makers can handle: pricing policy insights, product lifecycle management, and capacity management to confront strategic type questions.

3 - Determinants of Corporate Bankruptcy: Identification and Uncertainty

Tianhai Zu, University of Cincinnati, Cincinnati, OH, United States, zuti@mail.uc.edu, Yichen Qin, Yan Yu

Corporate bankruptcy is socially influential and economically detrimental. This paper explores various variable selection tools to identify important determinants of bankruptcy and constructing model confidence bounds to measure the reliability of the selected determinants. We further propose a graphical representation of the model selection distribution and define deviation and skewness measures to facilitate the understanding of the uncertainty of determinants. We find that among eight predictive variables in Campbell et al. (2008), price is identified with high confidence, while excess return is included within the model confidence bound, yet market to book ratio is outside the bound.

4 - Systemic Credit Freezes in Financial Lending Networks

James Siderius, Massachusetts Institute of Technology, Cambridge, MA, United States, jpsiderius@gmail.com

We consider a network model of financial intermediation where banks lend to and borrow from each other and supply funds to clients. A key decision for a bank is whether to extend credit to other banks, which may then default on those loans. In contrast to much of the previous literature on financial networks, the focus is on how "fear of future default" can lead to "credit freezes" before the realization of these uncertainties. Notably, credit freezes can happen in parts of the network that are not directly affected by increased uncertainty, both because the potential consequences of uncertainty travel throughout the network and also because such changes affect profitability of different loans.

5 - Reputational Impact on Startup Accelerator's Information Disclosure and Performance

Thunyarat Bam Amornpetchkul, NIDA Business School, Bangkok, Thailand, thunyarat.a@nida.ac.th

This study examines the implication of reputational concerns on a startup accelerator's decisions towards the effort exertion in a venture's quality certification process and the strategic information revelation policy. Our findings show that the accelerator's incentive to exert a high effort level in the startup accelerating program and disclose credible quality information is characterized by the reputational loss from misreporting the venture's quality and the size of the equity share that the accelerator receives from the venture's payoff.

■ MB60

CC- Chelan 4

QSR Orientations for Members

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Ran Jin, Virginia Tech, Blacksburg, VA, 24061, United States

Moderator

Ran Jin, Virginia Tech, Blacksburg, VA, 24061, United States

Qualifications and Expectations for Industrial R&D Work

William A. Brenneman, Research Fellow, Procter & Gamble Company, Cincinnati, OH, United States, brenneman.wa@pg.com

Panelists

- Jianjun Shi, Georgia Institute of Technology, H. Milton Stewart School of, Industrial and Systems Engr, Atlanta, GA, 30332-0205, United States
- Fugee Tsung, HKUST, Clearwater Bay Road, Hong Kong, Hong Kong
- Daniel Apley, Northwestern University, Dept of IEMS, Evanston, IL, 60208-3119, United States

■ MB61

CC- Chelan 5

Data Analytics for Engineering and Service System Improvement

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Di Wang, Peking University, Beijing, China

Co-Chair: Xi Zhang, Peking University, Beijing, China

Co-Chair: Kaibo Liu, UW-Madison, UW-Madison, Madison, WI, 53706, United States

1 - Scale-free Resilience of Real Traffic Jams

Daqing Li, Professor, Beihang University, Beijing, China, daqingl@buaa.edu.cn

The resilience represents the ability of a system to adapt and recover from various disturbances in natural and engineering systems. We define city traffic resilience based on the spatiotemporal clusters of jam in real traffic and find that the resilience follows a scale-free distribution in 2D city road networks and 1D highways with different exponents but similar exponents on different days and in different cities, and there is a scaling relation between the cluster size of the spatiotemporal jam and its recovery duration independent of microscopic details. Our findings can provide an indication for better understanding and design of system resilience under disturbances.

2 - Efficient Monitoring of Autocorrelated Poisson Counts

Jian Li, Xi'an Jiaotong University, , Xi'an, 710049, China, jianli@xjtu.edu.cn, Qiang Zhou, Dong Ding

Traditional monitoring of autocorrelated Poisson counts usually focuses on separately either the marginal mean or the autocorrelation coefficient. Inspired by multivariate SPC, we transform autocorrelated Poisson counts into a bivariate representation and propose an efficient chart. By borrowing the power from likelihood ratio test, albeit surprisingly, this chart demonstrates almost uniformly stronger power than the existing alternatives in simultaneously detecting shifts in both the marginal mean and the autocorrelation coefficient. Besides, we also show the proposed chart is fairly robust to overdispersion and has superiority in monitoring autocorrelated overdispersed counts.

3 - Reliability Inference for Degradation Process with Practical Effects Included

Qingpei Hu, Chinese Academy of Sciences, Academy of Math & Syst Science, 307 St East Zhonguan Cah, Beijing, 100190, China, qingpeihu@amss.ac.cn, Dan Yu

In order to conduct credible reliability assessment for the highly reliable products, practical testing factors should not be neglected, such as the inconsistency of product initial status, the recoverability with stress relaxation, and random lifetime delay due to complex failure mechanisms. In this talk, studies addressing the three practical issues in degradation process for reliability assessment would be presented, with more precise assessment approaches proposed. Corresponding planning issues are also explored.

4 - An Indirect Deep Learning Approach for Multisensor Degradation Modeling and Prognostics

Di Wang, Peking University, Beijing, China, dwang375@wisc.edu, UW-Madison, Madison, WI, United States, Kaibo Liu, Xi Zhang

With the development of sensor technology, multiple sensors have been widely used to monitor the degradation status of a unit simultaneously. As each sensor signal often contains partial and dependent information on the degradation status of a unit, effective fusion of such diverse sensor signals is important to better understand the degradation process of the unit. To address this issue, this paper proposes an indirect deep learning approach that constructs a health index by combining multiple sensor signals to better characterize the degradation process and provide accurate prognostic performance.

■ MB62

CC- Tahoma 1

Empirical Studies of Healthcare Process Quality and Patient Outcomes

Sponsored: Health Applications

Sponsored Session

Chair: Lesley Meng, The Wharton School, University of Pennsylvania, Philadelphia, PA, 19104, United States

Co-Chair: Benjamin Grant, Kellogg School of Management, Evanston, IL, 60201, United States

1 - Physician-hospital Integration and Financial Incentives

Jong Myeong Lim, The Wharton School of the University of Pennsylvania, Philadelphia, PA, United States, jongmlim@wharton.upenn.edu

Physicians and hospitals are traditionally separate entities where a patient who needs inpatient care is admitted to the hospital in which the responsible physician has an admitting privilege. As patients are critical inputs in the production of health care, hospitals have sought to build various forms of relationships with physicians. This paper examines the effect of physician-hospital integration in the form of employment contracts on hospital quality measured by patient experience. The results show that integration alone does not affect hospital quality but does improve quality in response to changes in financial incentives.

2 - Structural Estimation of Kidney Transplant Candidates' Quality of Life Score

A. Cem Randa, University of Chicago, Chicago, IL, United States, randa@chicagobooth.edu, Baris Ata, John Friedewald

This paper develops a framework for assessing the impact of changes to the deceased-donor kidney allocation policy on the transplant candidates' organ acceptance behavior. To be specific, it advances a dynamic structural model of the transplant candidates' accept/reject decisions for organ offers. Our formulation allows various important features of the transplant system as well as the heterogeneity in transplant candidates' quality of life scores. Using United Network of Organ Sharing (UNOS) data on transplant candidates, donors and organ offers, we first estimate the transplant candidates' quality of life scores. We then perform various simulation based counterfactual studie.

3 - The Physician Learning Curve for Quality and Cost Outcomes for Congestive Heart Failure Patients

Benjamin Grant, Kellogg School of Management, Evanston, IL, 60201, United States, Jillian Berry Jaeker, Hannah A. Jackson, R. Kannan Mutharasan, Nicholas Soulakis, Clyde Yancy, Jan A. Van Mieghem

Congestive Heart failure (CHF) has some of the highest readmission rates, mortality rates and cost of treatment. While the relationship between physician experience and improvement in health outcomes is documented for procedures, such as surgeries, it is not clear if this relationship is present for chronic illness care. We find evidence that recent accumulated physician experience, or learning, is associated with a reduction in readmissions, mortality, and costs for CHF patients.

4 - How Do Worker Schedule Characteristics Impact on Absenteeism, Turnover and Client Satisfaction? An Empirical Study of a Home Care Organization

Poonam Jassi, IE Business School, Madrid, Spain, Fabrizio Salvador

We investigate how absenteeism, turnover and client satisfaction are affected by the characteristics of workers' schedules using data from a home care organization covering 1,356,113 home visits done by 1,827 caregivers to 21,472 patients over 5 years. Preliminary findings indicate that different measures of schedule desirableness impact these outcomes and highlight possible heuristics to improve scheduling of caregivers.

5 - Improving Productivity: An Emergency Service System in which Cross-Trained Fire-Medics Respond to Medical Calls and Fire Incidents

Cheng Hua, Yale School of Management, East Haven, CT, 06512, United States, Arthur Swersey, Fernando Chiyoshi, Ana Paula Iannoni, Reinaldo Morabito

We focus on modeling and evaluating a novel emergency service system in which cross- trained fire-medics respond to both fire calls and medical emergencies. Fire demand in the U.S. has decreased dramatically in the last three decades, while emergency medical calls have surged. With this changing landscape, cities are under pressure to reduce their budgets by closing fire stations. We show that a better alternative would be to implement a fire-medic system in terms of cost savings and response time performance. Our model is original and contributes to the literature on stochastic models for service systems. A cross-trained fire-medic may be in one of three states: available, busy at an emergency medical incident, or busy at a fire call. We develop an exact spatial queuing model and an approximation method that solves two 2-state systems rather than a single 3-state system. We provide the convergence condition and demonstrate numerically that our algorithm will always converge in a few iterations. In several constructed examples, performance errors are very small compared to the exact model. We apply our model to the fire-medic system in St. Paul, Minn. and find close agreement between predicted and actual average response times. We compare St. Paul's system to a traditional system having separate engine and medical units with the same number of personnel, and show the very large response time reductions achievable under the fire-medic system. We also present conditions under which a fire-medic system in any city would outperform a traditional system. The fire-medic approach and our modeling have widespread applicability to cities in the U.S. and other countries.

■ MB63

CC- Tahoma 2

Joint Session HAS/Practice Curated: Data-Driven Models for Healthcare Applications

Sponsored: Health Applications

Sponsored Session

Chair: Emisa Nategh, University of Washington, Seattle, WA, 98105, United States

Co-Chair: Michael R. Wagner, Associate Professor, University of Washington, Seattle, WA, United States

1 - The Role of Machine Learning Models in End of Life Care

Margret Bjarnadottir, Assistant Professor of Man. Science and Statistics, University of Maryland, College Park, MD, United States, margret@rhsmith.umd.edu, David Anderson, Kim Rhoads

Predictions, driven by machine learning models of varying complexity, have become common place in the health care system. In this talk we will discuss the role of risk prediction in difficult decision making scenarios such as cancer and end of life care. We will present a case study of cancer survival predictions and their use.

2 - Optimization Methods for Fair Decisions

Matt Olfat, University of California Berkeley, Berkeley, CA, United States, molfat@berkeley.edu, Anil Aswani

Fair data-driven decision-making plays a pivotal role in the application of machine learning and computational techniques to healthcare, as it allows us to actively bar uninformative or undesirable correlations inherent in data from impact highly sensitive decisions. To that extent, we provide a series of fairness constraints that can be flexibly applied to the optimization underlying a number of training methods, for any number and type of protected attributes. We explore the strength of these constraints on a case study involving morphine dosage, as well as a number of other datasets.

3 - Did England's Policies on Sepsis and Antibiotic Resistance Have Their Intended Effects?

Spyros Zoumpoulis, INSEAD, Boulevard de Constance, Decision Sciences Area, Fontainebleau, 77305, France, spyros.zoumpoulis@insead.edu, Stephen E. Chick, Stephen Harris, Christos Oikonomou, Edward Palmer, Mervyn Singer

Sepsis is a life-threatening condition. The treatment guidelines of sepsis mandate the immediate use of antibiotics in suspected cases. However, the increase of antibiotic resistance has raised concerns regarding the appropriate usage of antibiotics. These concerns led to the design of policies in 2016 that target the potential excess usage of antibiotics in all levels of care. Using patient level data from intensive care units of several hospitals in England, we study the impact of such policies on the usage of antibiotics and health outcomes.

4 - Online Advance Scheduling with Overtime: A Primal-dual Approach

Esmaeil Keyvanshokooh, University of Michigan, Ann Arbor, Ann Arbor, MI, 48108-1020, United States, keyvan@umich.edu, Mark P. Van Oyen, Cong Shi

We study an online advance scheduling problem with reward and service time heterogeneity as well as budgeted overtime in which patients arrive one by one. Upon each arriving patient, the scheduler chooses both a resource and a day over a planning horizon without any information on the subsequent patients. By solving an online linear program, we design online optimization algorithms for this purpose and prove a worst-case performance guarantee. A case study of outpatient clinic scheduling is conducted.

5 - Predicting Treatment Related Toxicity and Efficacy in Multiple Myeloma from Clinical Entities Extracted from Amazon Comprehend Medical

Emisa Nategh, PhD, University of Washington, Seattle, WA, 98195, United States, emisan@uw.edu, David Coffey, Michael R. Wagner, Yong-Pin Zhou

Multiple myeloma is an incurable cancer and the second most common hematologic malignancy in the USA. While 19 drugs have been approved to treat the disease, these treatments are not effective for everyone. Hence, the goal of the treating oncologist is to choose a therapy that maximizes efficacy while reducing toxicity.The aim of our research is to develop a machine learning model to match patients to the most effective therapy while minimizing related toxicities. We are using Amazon Comprehend Medical to extract clinical entities from patient's medical records in order to train a model that identifies which clinical features are most informative for predicting toxicity and efficacy.

■ MB64

CC- Tahoma 3

Disease Screening, Diagnosis, and Management

Sponsored: Health Applications

Sponsored Session

Chair: Sze-chuan Suen, University of Southern California, Los Angeles, CA, 90089-0193, United States

1 - Optimizing Diabetes Screening Frequency for At-risk Groups

Sze-chuan Suen, University of Southern California, Los Angeles, CA, 90089-0193, United States, Chou-Chun Wu

BMI is a key risk factor for type 2 diabetes, but current guidelines do not provide BMI-category-specific screening frequency recommendations by age and prior testing history. We aim to determine the optimal policy with the above factors using a POMDP. We assume the physician has an estimate of the patient's health state (non-diabetic, prediabetic, or diabetic) at each period, and updates his beliefs about the patient's health given progression trends and observed test results. We show that our model has a threshold policy structure and find that the current recommended screening policy is suboptimal. High-risk individuals should be screened earlier and more frequently.

2 - The Impact of Transmission Patterns in Infectious Disease Simulations for Disease Control

Anthony Nguyen, University of Southern California, Los Angeles, CA, United States, nguyenac@usc.edu, Sze-Chuan Suen

Disease transmission patterns are often unknown but can have significant effects on disease prevalence and incidence over time. Modelers often use approximations for mixing patterns in infectious disease control simulations, but these may lead to suboptimal recommendations if the approximation is poor. We use individual-level sexual contact data among MSM from an HIV research center in Los Angeles to parameterize mixing pattern for a microsimulation model of HIV. We examine prevalence trends under homogeneous, race-specific, age-specific, and race-age mixing patterns. We additionally characterize PrEP and HIV screening interventions with projected prevalence under each scenario.

3 - Robust Partially Observable Markov Decision Process with Uncertain Parameters

Shan Liu, Assistant Professor, University of Washington, Seattle, WA, 98195-2650, United States, liushan@uw.edu, Jue Gong

Partially observable Markov decision process (POMDP) is an e ective tool in modeling decision making in uncertain and dynamic environment. We introduce two types of robust POMDP with uncertainties in the reward function and transition probabilities. The first model assumes parameters are bounded with linear constraints, and the second model assumes the transition probabilities follow Dirichlet distributions. We develop modified value iterations for each type of the POMDP to find optimal solutions. We illustrate the e ectiveness of our approach using a case study in designing personalized treatment plan for chronic depression in a heterogeneous population.

4 - A Data-driven Policy to Improve Newborn Screening for Cystic Fibrosis

Seyedehsaloumeh Sadeghzadeh, Assistant Professor, Binghamton University, Binghamton, NY, 24060, United States, Ebru Korular Bish, Douglas R. Bish

Cystic fibrosis (CF) is one of the most common genetic diseases in the United States, with an approximate prevalence rate of 1 in 3,700 newborns. Early diagnosis of CF, through newborn screening, substantially improves health outcomes, while a delayed diagnosis may lead to complications or even fatality. Therefore, newborn screening for CF is conducted throughout the United States. We propose optimal data-driven approaches, based on a five-year data set from the North Carolina State Laboratory of Public Health, and show that our proposed screening policies, which are easily implementable, substantially improve the screening outcomes.

5 - Identifying Optimal Screening Schedules for Breast Cancer in Low- and Middle- Income Countries: Application to Peru

Xinmeng Zhao, University of Massachusetts-Amherst, Amherst, MA, United States, xinmengzhao@umass.edu, Shifali Bansal, Vijeta Deshpande, Jeremy A. Lauer, Filip Meheus, André Ilbawi, Chaitra Gopalappa

Due to late-stage diagnosis, a large proportion of cancer deaths, about 70%, occurred in low-and-middle-income countries (LMICs). Early diagnosis of breast cancer through mammography screening can significantly reduce premature mortalities, as evidenced in high-income countries (HICs). Current guidelines for mammography screening are infeasible to implement in most LMICs due to infrastructure unavailability. Current guidelines are extrapolations of modeling studies conducted in HICs since data challenges limit the development of models specific to LMICs. We discuss model development and Markov decision process analysis to identify optimal mammography screening schedules for Peru.

■ MB65

CC- Tahoma 4

Joint Session HAS/Practice Curated: Evaluating Interventions for Diabetes Care

Sponsored: Health Applications

Sponsored Session

Chair: Maria Esther Mayorga, North Carolina State University, Raleigh, NC, 27695, United States

1 - Evaluating Engagement Patterns of Using a Mobile App for Diabetes Self-Management among Older Adults and Effects on Outcomes

Shinyi Wu, University of Southern California, Los Angeles, CA, 90015, United States, shinyiwu@usc.edu, Haomiao Jin

Mobile diabetes applications (app) can be a useful tool. Few studies assessed older adults' app use and effects. This study investigated 334 community-dwelling older adults with type 2 diabetes taught to use an app. Trajectory clustering analyses identified three distinct longitudinal engagement classes of individuals. The relationships between the app engagement class memberships and 4- and 8-month diabetes outcomes were assessed using an econometric regression analysis approach. The results showed the degree of app engagement was positively correlated with diabetes self-care scale scores. Only the engagement on the blood sugar function significantly associated with HbA1c improvement.

2 - Evaluating Screening and Care of Diabetic Retinopathy in Veterans Using Mixed-integer Programming and Simulation

Adam VanDeusen, Doctoral Candidate, University of Michigan, Ann Arbor, MI, United States, ajvandeu@umich.edu, April Maa, Amy Cohn

Veterans report greater delays in seeking care than non-veterans. Veterans also experience higher prevalence of diabetes, which is a significant risk factor for eye disease, including diabetic retinopathy. These factors contribute to a need for more accessible eye care in Veterans Administration (VA) healthcare facilities. We evaluate VA eye care facility location options, including implementing trained technicians to perform visual disease screenings typically conducted by ophthalmologists. We review how these screening models can be expanded to consider follow-up care using simulation. Our work may guide decision-makers in locating and staffing clinics to improve patient access.

3 - A Multi-scale Co-designed Simulation Model for Gestational & Type 2 Diabetes

Nathaniel D. Osgood, PhD, University of Saskatchewan, Saskatoon, SK, Canada, nathaniel.osgood@usask.ca, Yang Qin, Louise Freebairn, Jo-An Atkinson, Roland F. Dyck

We describe a multi-scale model capable of addressing interventions that can be involving any combination of targeted individual focus, innovations in health service delivery, and population level programs within the ACT. We particular highlight the way in which such flexibility is enabled via integration of physiological, individual-level, granular characterization of clinical pathways and public health levels of analysis realized via combinations of 3 types of dynamic modeling. We further describe the broadly consultative and closely interdisciplinary team effort that made model development possible, and the grounding of the model in diverse sources of empirical understanding.

4 - An Analytics-driven Approach for Optimal Individualized Diabetes Screening

Hossein Kamalzadeh, Southern Methodist University, Dallas, TX, United States, hkamalzadeh@smu.edu, Michael Hahsler, Vishal Ahuja, Michael Bowen

About 10% of the US adult population has diabetes, and almost 40% are at risk of developing diabetes. Guidelines suggest population-based screening, however, in resource-restricted settings (e.g., for safety-net providers), prioritizing whom to screen and when is essential. We combine analytics methods (hidden Markov models and predictive analytics) with partially observable Markov decision process models to derive the optimal screening policy customized to the characteristics of the provider's subpopulation. We will present results for electronic health record data from the Parkland Health & Hospital System.

5 - Identification and Prioritization of Barriers to Care for Patients with Diabetes

Breanna Swan, North Carolina State University, Raleigh, NC, 27703, United States, bpswan@ncsu.edu, Maria Esther Mayorga, Julie Simmons Ivy

This work identifies and prioritizes barriers to coordinated care between patient and provider, focusing on screening and treatment for microvascular complications. Patients progress through disease states according to a Markov model and interact with the care system through a discrete event simulation model. Interventions to improve adherence and to overcome impactable barriers to care already identified in literature will be tested through the simulation model and prioritized to improve effectiveness, efficiency, and quality of care from diagnosis to treatment.

■ MB66

CC- Tahoma 5

Emerging Topics in Personalized Medicine I

Emerging Topic: Personalized Health

Emerging Topic Session

Chair: Marina A. Epelman, University of Michigan, Ann Arbor, MI, 48109-2117, United States

1 - Brachytherapy Plan Generation Using Pareto Surface Generation, Visualization, and Navigation

Marina A. Epelman, University of Michigan, Ann Arbor, MI, 48109-2117, United States, mepelman@umich.edu, Victor Wu, Christopher Deufel, Mustafa Y. Sir, Kalyan Pasupathy

In designing radiation therapy treatment plans, multiple instances of the planning optimization problem need to be solved to identify the trade-off between treatment objectives best for each patient. In high-dose brachytherapy, efficient exploration of these trade-offs is especially important, since the patient experiences discomfort or is under anesthesia while awaiting the generation of the treatment plan. We propose a methodology for fast generation, visualization, and navigation of approximate Pareto surfaces of dose-volume metrics, which are approximated via convex "truncated CVaR" functions to account for long upper tails common in dose distributions in brachytherapy treatments.

2 - Learning from Clinical Time-series

Jenna Wiens, University of Michigan, Ann Arbor, MI, United States

Recurrent neural networks (RNNs) are commonly applied to clinical time-series data with the goal of learning risk stratification models. Their effectiveness is due, in part, to their use of parameter sharing. We hypothesize, however, that this trait contributes to the increased difficulty such models have with learning relationships that change over time. We illustrate the advantages and disadvantages of complete parameter sharing on three clinically-relevant prediction tasks: acute respiratory failure, shock, and in-hospital mortality. To improve upon the dichotomy between complete parameter sharing vs. no parameter sharing, we propose a novel RNN formulation based on a mixture model in which we relax parameter sharing over time. The proposed method outperforms standard LSTMs and other state-of-the-art baselines across all tasks.

3 - Logic-based Benders Approach for the Kidney Paired Donation Problem

Carolina Riascos, University of Toronto, Toronto, ON, Canada, Dionne Aleman, Merve Bodur

Kidney paired donation consists of patients exchanging their donors with others so that they can obtain a suitable kidney. Those exchanges are in the form of cycles and chains and have an associated priority. The kidney exchange problem is to find a collection of vertex-disjoint chains and cycles of a given size in a directed graph. The problem is NP-hard and challenging for real-sized instances. The literature has addressed it mainly by designing Branch and Price approaches. We develop the first Logic-based Benders Decomposition in the literature for this problem. Our computational results show the advantage of our model for large instances and a sensitivity analysis for various matching priorities.

4 - A Simulation Framework to Leverage Patient-specific Data in Improving Cardiac Intensive Care Unit Utilization

Amanda D. Moreno-Hernandez, University of Michigan, Ann Arbor, MI, 48103, United States, admh@umich.edu, Amy Cohn

We present a simulation framework to model the operations of a cardiac ICU at the Michigan Medicine Cardiovascular Center (CVC). Patients receiving care in the CVC for critical cardiac conditions arrive through many different channels (e.g. the emergency department, inpatient wards, and transfer from other institutions when advanced care is warranted). These patients also vary in their medical diagnosis, condition, and their genetic, socio-economic, and other characteristics that impact their care needs. Our aim is to provide flexibility in analyzing operational policies and procedures, enabling patient information of any level of detail to be used to improve the granularity of the model.

■ MB67

S- Virginia

Empirical Studies in Healthcare Operations

Sponsored: Manufacturing & Service Oper. Mgmt/Healthcare Operations

Sponsored Session

Chair: Maria Ibanez

1 - Who is an Efficient and Effective Physician? Evidence from Emergence Medicine

Raha Imanirad, Harvard Business School, Boston, MA, 02472, United States, rimanirad@hbs.edu, Soroush Saghafian, Stephen Traub

Improving the performance of the healthcare sector requires a deep understanding of the efficiency and effectiveness of care delivered by physicians. Despite recent advances, scientific methods of measuring efficiency and effectiveness of physicians have proven elusive. We utilize a large data set along with Data Envelopment Analysis (DEA) to shed light on scientific metrics that can gauge physician performance in terms of efficiency and effectiveness. We use machine learning tools to validate our DEA scores. In addition, we carry out a Tobit analysis to identify factors related to physician, patient and peer characteristics that are associated with higher levels of physician performance.

2 - Is Good Research Worth it? How Compliance with Best Scientific Standards Affects Academic Scientists and Firms

Maryaline Catillon, Harvard Business School, Wyss Doctoral Office, Boston, MA, 02163, United States, mcatillon@hbs.edu

The reproducibility crisis has sharpened focus on research quality. Previous research has modelled academic scientists and firms' incentives to produce high quality science. This paper builds on a new database to ask, empirically, how compliance with best scientific standards affects scientific impact and evidence driving sales. I find that better methods are associated with higher scientific impact. However, better methods reduce the probability of reaching positive results, and are not associated with measures affecting drug sales. Altogether, these results suggest that it may be in more of a academic scientist's interest than a pharmaceutical company's interest to use adequate methods.

3 - Incident and Near Miss Reporting in Radiation Oncology

Olivia S. Jung, Doctoral Student, Harvard Business School, Harvard Business School, Boston, MA, United States, ojung@hbs.edu, Palak Kundu, Amy C. Edmondson

Near misses—harm averted due to chance or intervention—present a low-cost learning opportunity. To study whether near misses are reported and perceived as success or failure, we surveyed radiation oncology staff and linked responses to submissions. Respondents were more likely to indicate willingness to report (WTR) scenarios deemed as failure than success. Those expressing higher psychological safety were more likely to indicate WTR for scenarios due to a human error that led to a proximate negative outcome. We observe differences in submission of incidents by role, suggesting impact of hierarchy on likelihood of reporting.

4 - Decomposing Volume's Impact on Judgment and Skill: Lessons from Kidney Transplantation

Philip Saynisch, National Committee for Quality Assurance, Washington, DC, 02128, United States, Robert Huckman, Nikolaos Trichakis

In markets for credence goods, suppliers act both providers and expert advisors. This dual role complicates learning-by-doing explanations of the volume-outcome relationship: improvements may result from better judgment or better skill. This paper explores kidney transplantation, where clinical decision-making and surgical performance are separately observable. We find that greater volume is associated with improved post-transplant outcomes, but worse decision-making. This tension between improved skill and reduced quality of judgment implies that practice may not make perfect in complex medical decision-making.

■ MB68

S- University

Urban Air Transport II

Emerging Topic: Sharing Economy & Crowdsourcing

Emerging Topic Session

Chair: Laurie A Garrow, Georgia Institute of Technology, Atlanta, GA, 30332-0355, United States

Co-Chair: Alexandre Jacquillat, Carnegie Mellon University, Pittsburgh, PA, 15213, United States

1 - Commuting in the Age of the Jetsons: Mode Choice between Autonomous Ground Vehicles and Air Taxis in Five Large U.S. Cities

Laurie A. Garrow, Georgia Institute of Technology, School of Civil & Environmental Engineering, Atlanta, GA, 30332-0355, United States, laurie.garrow@ce.gatech.edu

Imagine a world where instead of sitting in traffic on the downtown connector, you could simply drive to a vertiport near your home, enter into a small electric propulsion aircraft, fly over traffic, land on a rooftop near your work, and either walk or have an rideshare vehicle take you to your office. In this presentation, we provide an overview of ongoing research in air taxi flights for cities and present results from two surveys we conducted of commuters in five cities in the U.S. to estimate commuting demand and willingness to pay for these air taxi flights and competition with self-driving cars.

2 - On-demand Urban Aerial Mobility: Strategic Vertiport Network Design

Kai Wang, The Hong Kong Polytechnic University, Kowloon, Hong Kong, kai.k.wang@connect.polyu.hk, Alexandre Jacquillat, Vikrant Vaze

Urban Aerial Mobility (UAM) will rely on a network of vertiports—where electric vertical-takeoff-and-landing (eVTOL) aircraft will be operated. This paper optimizes the number, location, and capacity of vertiports while capturing the interdependencies between strategic vertiport deployment, tactical eVTOL operations, and customer adoption. This is cast as a nonlinear mixed-integer model, embedding a queuing network model of UAM operations and a robust optimization model of customer adoption. We propose an iterative discretization algorithm to reformulate it as a second-order conic program and obtain a high-quality solution. Results provide insights on future UAM systems in urban areas.

3 - By Schedule or on Demand? – A Hybrid Operational Concept for Urban Air Mobility

Syed Arbab Mohd Shihab, Iowa State University, Ames, IA, United States, Peng Wei, Rodrigo Mesa Arango, Christina L. Bloebaum

Taking into account the unique set of operational constraints associated with Urban Air Mobility services, this paper proposes mathematical models for commercial transport service providers to decide which type of scheduling to offer, how many vehicles to deploy and how to dispatch resources based on simulated market demand such that profit is maximized. Three different settings of services - on-demand service, scheduled service, and a mix of both services (hybrid operations) - are considered.

4 - A Risk Assessment Framework for Communications in Autonomous Air Traffic Operations

Karthik Gopalakrishnan, Massachusetts Institute of Technology, Cambridge, MA, 02139, United States, karthikg@mit.edu, Hamsa Balakrishnan, Vanessa Kuroda

Robust, reliable, and effective communications are essential for the safe integration of autonomous aircraft into the air traffic control system. Emerging applications such as Urban Air Mobility (UAM) and Unmanned Aircraft Systems (UAS) in turn rely on such autonomous air traffic operations. We develop a framework to assess vulnerabilities and threats in air traffic communications. We present an analysis of the likelihood and impact of a set of 'atomic attacks' on elements of the communications network, assess the risk levels of individual elements, and identify mitigation strategies. Finally, we use the proposed methodology to evaluate the robustness of candidate UAM architectures.

■ MB69

S- Seneca

SpORts Analytics II

Sponsored: SpORts

Sponsored Session

Chair: Kent J Kostuk, Federated Co-Operatives Limited, Saskatoon, SK, S7J 2T2, Canada

1 - Assessing NFL Team Performance using Points Added

Martin L. Puterman, University of British Columbia, Sauder School of Business, Vancouver, BC, V6T 1Z2, Canada, martin.puterman@sauder.ubc.ca, Tim Chan, Craig Fernandes

In this talk we provide a rigorous foundation for estimating and interpreting value functions in NFL (American professional) football based on the Poisson equation for Markov reward processes and martingale theory. We then use the value function to construct a "points added per play" metric and show how this metric can provide insights into why the New England Patriots won the 2019 Super Bowl.

2 - Do You Ever Not Want to Bat Last?

Kent J. Kostuk, Industrial Engineering Manager, Federated Co-Operatives Limited, Saskatoon, SK, S7J 2T2, Canada, kent.kostuk@usask.ca, Keith A. Willoughby

During the round robin portion of a softball tournament most events use runs for and against as a team ranking criteria in addition to wins and losses. Traditional thinking suggests that you maximize your success by having last at bat. Some teams elect to be the visiting team to guarantee they maximize their offensive opportunities. We will investigate which approach will provide the best outcome and under what circumstances.

3 - Automatic Event Detection in Basketball Using Hidden Markov Model with Energy Based Defensive Assignment

Min-hwan Oh, Columbia University, New York, NY, 10027, United States, m.oh@columbia.edu, Suraj Keshri, Sheng Zhang, Garud N. Iyengar

We propose an unsupervised learning framework for automatically labeling events in a basketball game. We first learn the time series of defensive assignments using a novel player and location dependent attraction based model which uses hidden Markov models (HMMs), Gaussian processes, and a "bond breaking" model for changes in defensive assignments. Next, we use the learned defensive assignments as an input to a set of HMMs that automatically detect play actions. We show that our models provide significant improvements over existing benchmarks both on defensive assignments and event detection.

4 - Does Sports Analytics Work Part Three

Walt DeGrange, CANA Advisors, Chapel Hill, NC, 27517, United States, wdegrange@canallc.com

With the recent success of sports teams heavily using analytics (Red Soxes, Patriots, Capitals, Warriors, Manchester City F.C.), does this mean that analytics has gained a foothold in the sports world? And if so, is there a career path that a high school student can use to become a sports analytics professional? This presentation builds on two prior years of analysis and adds another year of professional team results and additional factors.

5 - Pay Per View Pricing in a Subscription Model

Mike Gordon, University of Pittsburgh, Pittsburgh, PA, 15224, United States, m.gordon@pitt.edu

We analyze pay-per-view pricing on a subscription platform. This model accounts for consumer technological abilities along with illegal streaming.

■ MB70

S- Jefferson A

Online Platforms

Sponsored: EBusiness

Sponsored Session

Chair: Guneet Kaur, University of Connecticut, Storrs Mansfield, CT

1 - How to Share Prosocial Behavior Without Being Perceived a Braggart?

Xue Tan, Indiana University, Kelley School of Business, Bloomington, IN, 47405, United States, janetan@iu.edu, Lu Yan, Alfonso J. Pedraza-Martinez

People are reluctant to share their prosocial behavior on social media because by announcing their good deeds, they run the risk of being perceived as braggers. However, by keeping silent, they run the risk of receiving no credits for their effort. This is the braggart's dilemma. In this study, we use both empirical evidence and lab experiments to show that by acknowledging a third party in the announcement of prosocial behavior, one will be perceived highly due to less suspicion of bragging. Specifically, we find that when an individual shows gratitude to the corporate sponsor of his prosocial activity in the social media post, he will obtain more positive social reactions.

2 - The Impact of Crime on the Sharing Economy: A Spatial Analysis

Chenhui Guo, Michigan State University, Lansing, MI, United States, guochen8@msu.edu, Inkyu Kim, Anjana Susarla

We analyze the impact of crime on demand for the sharing economy in urban areas. In particular, we are interested in how features of the sharing economy associated with deterrence could internalize some of the negative externalities caused by crime. By conducting aggregate demand estimation at the neighborhood level, we find evidence that the sharing economy provides a positive social benefit to individual establishments through deterrence features. We also consider alternate explanations that results could be driven by gentrification in neighborhoods. Our results suggest that the sharing economy might provide some social insurance to neighborhoods.

3 - Does Illusionary Progress Make You Exercise More?

Guneet Kaur, University of Connecticut-Storrs, Mansfield, CT, United States, guneet.kaur@uconn.edu, Xinxin Li, Jing Peng

We study the impact of illusionary progress, i.e., endowing progress while increasing the goal by the same amount, on both short-term participation in gym exercises and habit formation reflected in long-term participation. We run a randomized field experiment in collaboration with a gym. To moderate the effect of illusionary progress on enhancing overconfidence about future self-control, we introduce social comparison as a second intervention by showing members the top scores of their peers a month after the experiment starts. By also studying moderating factors such as app usage, the study has important implications about how to use fitness apps to motivate people to exercise and stay healthy.

■ MB71

S- Jefferson B

Channel Relationships and Planning Decisions

Sponsored: Behavioral Operations Management

Sponsored Session

Chair: Eirini Spiliotopoulou, Tilburg University, Tilburg, Netherlands

1 - A Behavioral Investigation of the Demand Allocation Game

Yinghao Zhang, University of Cincinnati, Cincinnati, OH, 45221, United States, yinghao.zhang@uc.edu, Tianjun Feng, Lin Tian, Lin Tian

We consider a situation with two competing retailers who make inventory decisions. The total market demand is divided proportional to their stocking levels. Experimental results suggest that human subjects' decisions systematically deviate from the Nash Equilibrium. We use theory of reciprocity to explain this off-equilibrium behavior.

2 - Inventory Rationing Across Channels

Eirini Spiliotopoulou, Tilburg University, Netherlands, e.spiliotopoulou@uvt.nl, Nienke Hofstra

When demand exceeds available inventory, suppliers ration their inventory among sales channels. How does inventory risk and payment schemes affect allocation decisions in such cases? We conduct lab experiments to study the role of risk aversion, loss aversion and mental accounting in inventory allocation decisions between two channels. On average, subjects allocate significantly less inventory than the expected profit maximizing quantity to the risky, yet more profitable, channel. Subjects with stronger risk appetite allocate larger quantities to the risky channel, but also exhibit higher loss aversion. Risk attitude moderates the effect of the timing of payments on allocation decisions.

3 - Long-term or Short-term Suppliers under Dual Sourcing? Behavioral Evidence from an Order Allocation Game

Wanshan Zhu, Tsinghua University, Beijing, China, Chao Xue, Diana (Yan) Wu, Xiaobo Zhao

We consider a supply chain setting where a manufacturer needs dual sourcing to meet demand. To benefit from quantity discounts, the buyer has to unevenly allocate his demand between two suppliers, generating dependence asymmetry under the triadic channel.To investigate the sourcing strategy as to whether long-term or short-term suppliers should be employed, we manipulate the matching protocol within a triad to be either fixed or random in the experiments. We observe behavioral differences between the two suppliers under both matching conditions, and dynamics in the manufacturer's decisions. Behavioral models are developed to provide further managerial insights for dual sourcing.

4 - Judgmental Adjustments in Forecasting: Implications and a Strategy for Improvement

Rob Basten, Eindhoven University of Technology, Eindhoven, Netherlands, R.J.I.Basten@tue.nl, Bregje van der Staak, Philippe Van de Calseyde

We analyze how planners adjust statistical sales forecasts. In an initial data set with more than 55,000 sales forecasts and outcomes, we consistently find that planners perform worse than the statistical forecasting algorithm when making upward adjustments, but are highly accurate in predicting whether the statistical forecast should go up or down. These findings are used in a follow-up study, using more than 12,000 new forecasts to test what happens when planners decide on the direction of the adjustment, while the algorithm decides on the magnitude of the adjustment. We thus significantly reduce the forecasting error by on average 17%.

■ MB72

S- Columbia

Online Ratings & Reviews

Sponsored: Information Systems

Sponsored Session

Chair: Arslan Aziz

1 - The Effects of Online Review Platforms

Limin Fang, The University of British Columbia, Vancouver, BC, Canada, limin.fang@sauder.ubc.ca

This paper quantifies the effect of online review platforms on restaurants and consumer welfare. Using a novel dataset containing restaurant revenues and information from major online review platforms, I show that these platforms help consumers learn faster about restaurant quality. In particular, they increase the revenue and survival rates of high-quality independent restaurants and decrease those of low-quality restaurants, but have little effect on chains or old independent restaurants. Based on the evidence, I develop a structural demand model with social learning. Counterfactual analyses show online review platforms improve the welfare for restaurant goers by $2.5 per person per meal.

2 - Reputation Inflation

Apostolos Filippas, Assistant Professor, KMC, New York, NY, 10012, United States, apostolosfilippas@gmail.com, John Joseph Horton, Joseph Golden

A solution to marketplace information asymmetries is to have trading partners publicly rate each other post-transaction. Many have shown these ratings are effective; we show that their effectiveness deteriorates over time. The problem is that ratings are prone to inflation, with raters feeling pressure to leave "above average" ratings, which in turn pushes the average higher. This pressure stems from raters' desire to not harm the rated seller. As the potential to harm is what makes ratings effective, reputation systems, as currently designed, sow the seeds of their own irrelevance.

3 - The Platform Value of a Review

Andrey Fradkin, Boston University, Cambridge, MA, 02139, United States

Online reviews are public goods and are consequently underprovided in equilibrium. In order to correct for this, digital platforms may incentivize reviews through payments or coupon offers. In this paper, we use a large scale field experiment in incentivized reviews to study the value of these reviews to the platform. We evaluate the effects of reviews induced by this policy on the reviewed sellers, the buyers who subsequently transact with these sellers, and the reviewers themselves. We show how the value of a review varies with market conditions on the platform.

4 - How Rating Inflation Affects Consumer Purchase

Arslan Aziz, Assistant Professor, The University of British Columbia, Vancouver, BC, V6S 0K4, Canada, Hui Li, Rahul Telang

Even as online ratings become an increasingly important source of product quality information, they are plagued by a number of systematic biases that cause them to be inflated. In this paper, we conduct a novel quasi-field experiment that exogeneously induced rating inflation on a food delivery platform. We investigate the consequences of this induced rating inflation on consumer purchasing behavior. We find that rating inflation reduces a consumer's degree of trial as well as their average spend per transaction. Inflated ratings are perceived as less informative by consumers which makes trial riskier.

5 - Speech Is Silver, Silence Is Golden: Evidence from a Field Experiment on Motivational Framing Backfiring

Aishwarya Deep Shukla, Assistant Professor, Simon Fraser University, Vancouver, BC, Canada, adshukla@sfu.ca, Tianshu Sun, Guodong (Gordon) Gao, Ritu Agarwal

Online Word of Mouth (WOM) is economically significant, but there is a lack of empirical evidence on strategies to stimulate WOM. We ran a field experiment on a digital healthcare platform to test the effectiveness of message framing. Contrary to prior research, our results show that motivational email framing backfires. It reduces WOM quantity and has no significant effect on WOM quality. Findings suggest that explicit messaging to induce motivation, i.e., specifying reasons why a user should contribute, reduces the volitional drive to contribute. This is plausibly because such framing converts the implicit motivation into an obligation, suppressing the desire to contribute.

■ MB73

S- Boren

Transformative Impact of IT

Sponsored: Information Systems

Sponsored Session

Chair: Jingyang Zheng

1 - Would Users Post More? A Hidden Markov Model of Review Learning Dynamics in User-generated Content Platform

Zheng Fang, Purdue University, West Lafayette, IN, United States, fang227@purdue.edu, Jinyang Zheng, Karthik Kannan, Guopeng Yin

Review-in-review (RIR) is a function that information technology companies apply to collect users' valuation of the generated content. Users could click "helpful", "unhelpful" or write "review" to the content they read. RIR would reshape the content generating process since users' behavior would be influenced by RIR. To evaluate the effectiveness of our idea, we root our research in the context of a movie review platform and we implement the Hidden Markov Model (HMM) to capture the learning dynamics of users based on their unobserved learning patterns. We estimate the learning state of users on a daily basis and it shows significant evidence that RIR would influence users' content generating process.

2 - Estimate the Value of Destination Disclosure: A Dynamic Structural Model of Transportation Network

Weilong Wang, Purdue University, 403 W. State St, West Lafayette, IN, 47907, United States, wang4167@purdue.edu, Jinyang Zheng, Karthik Kannan, Fei Ren

The efficiency of taxi services in big cities influences not only the convenience of peoples' travel but also urban traffic and profits for taxi drivers. With the help of information sharing, many efforts have been made to improve transportation system, i.e. ridesharing platform. Our results show that our method improves profits and efficiency for taxi drivers and increases matching probability between passengers and taxi drivers. Based on our setting, several different policies are evaluated to test the impact of information on both passengers and drivers.

3 - Alexa Shopping: The Effect of Voice Assistants on Consumer Purchase and Search Behavior

Chenshuo Sun, New York University, New York, NY, 10011, United States, Xiao Liu, Anindya Ghose

A voice assistant, such as Amazon's Alexa, is a wireless device with artificial intelligence that can be activated by voice command. Increasingly, consumers are using voice assistants for shopping. However, little is know about the effect of voice assistants on consumer purchase and search behaviors. We collaborate with one of the largest online retailers in the world and run a field experiment to answer the following three research questions: 1) How does a voice assistant (VA) affect search and purchase behavior? 2) Does a VA lead to a category expansion effect or a store switching effect? and 3) Does a VA affect search breadth or search depth? We combine a machine learning method and a causal inference method to deal with the two-sided non-compliance issue in the experiment and estimate heterogeneous treatment effects. We find that a voice assistant can increase consumer purchase and search on the associated e-commerce site. The increase in purchase comes from both the category expansion effect in the smart home category and the store switching effect in the repeatedly-purchased FMCG category. A voice assistant leads to a larger increase in search breadth than in search depth. These insights can help online retailers with category planning decisions and help brands with voice search engine optimization strategies.

4 - What Can Physician-Generated Content Tell Us? Evidence from Healthcare Recommender System

Jianing Ding, Purdue University, West Lafayette, IN, United States, ding246@purdue.edu, Susan F. Lu, Karthik Kannan

The unified medical information system becomes much more crucial in the entire healthcare industry. Motivated by the desire of providing more appropriate medical care to each patient with taking the advantages of information techniques, we focus on physician-generated content posted in the healthcare recommender system (unlike prior studies which focus on patient-generated content) and attempt to explore the value hidden in those self-expression content. To achieve this goal, we then provide a predictive test of the measure by applying it to a sample of more than 5,630 physicians of 280 hospitals in state Florida to explore the direct impacts of physicians' personality traits on their job performance, discharging habits, and treatment efficiency. Our analyses show that the patient treated by the physician with higher score in openness is more likely to achieve better efficacy, reduce expenditure, and save time in treatment. In contrast, the conscientious physician tends to charge more and spend more time on lab test with no enhance in performance. Furthermore, the underlying mechanism reveals causal effect of personality traits on physician's performance, discharging habits, and treatment efficiency. The methods we introduce can be used to analyze the impact of personality in other fields, and suggest that consumers need to take into account the personality effects of service providers when making decisions.

5 - When Donation Meets Reward: An Empirical Examination of Contribution Dynamics in Crowdfunding

Yipu Deng, Purdue University, West Lafayette, IN, 47906, United States, deng127@purdue.edu, Jinyang Zheng, Guoxin LI, Karthik Kannan

With the growing popularity of crowdfunding, it is necessary to understand the behavior of backers. In this study, we empirically examine peer influence and signaling theory in a reward-based crowdfunding market. Further, we investigate how the content of projects' description influence subsequent crowdfunding behavior (i.e., donating and contributing). We find evidence in support of a crowding-out effect, where the increase in the volume of prior period contribution/donation is associated with a decrease in subsequent contribution/donation. Besides, fundraisers' own support behaviors could encourage more backers. Finally, more subjective project titles will repel potential backers.

■ MB74

S- Capitol Hill

Gender Gap

Sponsored: Women in OR/MS (WORMS)

Sponsored Session

Chair: Margarit Khachatryan, MagAnalytics, St. Louis, MO, 63044, United States

1 - Using Simulation Modeling to Examine Policy Effects on the Workforce Outcomes of Women in Academic Science

Julie A. Maurer, Ohio State University, Columbus, OH, 43210, United States

Despite gains made over the past 20 years toward gender pay equity for female scientists working in academic research, a persistent gap suggests that existing policies have not gone far enough. Insights into how the workforce structure, institutional policies and employer preferences interact to impact the career development of female scientists using ABM and SD modeling will be shared.

2 - Do Less Discretionary Tenure-clock Extension Policies Improve Career Outcomes among New-parent Faculty?

Maryam Andalib, Data Scientist, Ford Motor Company, Dearborn, MI, United States, maryam.andalib@gmail.com, Joshua Hawley, Navid Ghaffarzadegan

Tenure-track faculty often experience high stress levels affecting their career, mental health, and work-life balance. Childbearing and childrearing, which coincide with the tenure probationary periods of 45% of the faculty, exacerbates the situation. To support faculty members in special life circumstances universities use policies to extend the tenure clock (TCE). Based on data from top 250 U.S. universities, we answer the following question: "How does automatically extending the tenure probationary period of new parents affect their career outcomes?" We discuss the findings and implications.

3 - Gender Gap and Microaggressions at a Workplace

Liana Babayan, Augusta University, Augusta, GA, United States

Although much has been studied on damaging consequences of everyday prejudice, gender bias, harassment and discrimination upon marginalized groups in a typical workplace, it still remains difficult to define and examine the discrimination that occurs via implicit bias. Subtle sexism and microaggressions continue to have significant negative impact on women, resulting in anger and frustration, lack of productivity; and often keeping them from potential promotions and professional advancement. In the era of #metoo movement, where sexual harassment is getting more and more coverage, the microagressions taking place in professional settings need to be taken just as seriously, since they not only have the potential to perpetuate the gender bias, hence the gender gap but also are symptoms of potential sexual harassment or coercion. To successfully and systematically fight against this common type of discrimination and to thrive for a more financially and emotionally equitable workplace, it is imperative to understand how those microagressions attack underrepresented groups; and study their detrimental economic consequences on women at a workplace. This study looks into different types of microagressions against professional women and offers a discussion on how to engage in a productive fight for a fair workplace.

■ MB77

S- Fremont

Scheduling III

Emerging Topic: Project Management & Scheduling

Emerging Topic Session

Chair: Yumei Huo, City University of New York, College of Staten Island, Staten Island, NY, 10314, United States

1 - Multitasking Scheduling with Controllable Processing Times

Yan Wang, Northwestern Polytechnical University, Xi'an, China, pacpos.ywang@gmail.com, Junqiang Wang

We investigate a single-machine multitasking scheduling problem subject to unlimited or limited resource availability. The job processing times are controllable as a linear or convex function of the amount of a common continuously divisible resource allocated to the jobs. We study several problems in terms of different objective functions and processing time functions. We provide structural properties of the optimal schedules and polynomial-time algorithms for the considered problems.

2 - Bi-criteria Ant Colony Optimization Algorithm for Minimizing Makespan and Energy Consumption on Parallel Batch Machines

Zhaohong Jia, Anhui University, Hefei, China, zhjia@mail.ustc.edu.cn

We investigate the problem of minimizing makespan and electric charge simultaneously on batch-processing machines with different-size jobs. A Pareto-based ant colony optimization algorithm is proposed. Depending on delaying the batch or not, two candidate lists are constructed to select jobs. Moreover, heuristic information is designed for each candidate list to guide the search. In addition, objective-oriented local optimization is applied to improve solution quality. Results of comparative experiments indicate that the proposed algorithm outperforms several other state-of-the-art algorithms, especially on large-scale problems.

3 - Approximation Algorithms for Parallel-batch Scheduling with Processing Set Restrictions

Wenhua Li, Zhengzhou University, Zhengzhou, China, liwenhua@zzu.edu.cn, Xing Chai, C.T. Ng, T.C E. Cheng

We consider job scheduling on m parallel-batch machines to minimize the makespan. Each job has a given set of machines to be assigned. Each machine can process several jobs simultaneously as a batch. We study two models: (i) scheduling on parallel-batch machines with the nested processing set restrictions and (ii) scheduling on uniform parallel-batch machines with the tree-hierarchical processing set restrictions. For the first model, we design a strongly polynomial-time solution algorithm. For the second model, we design two fast algorithms for the case with non-identical batch capacity and the case with identical batch capacity, respectively.

4 -Revisit Heuristics for Flowhsop Scheduling with Availability Constraint

Yumei Huo, City University of New York, College of Staten Island, Staten Island, NY, 10314, United States

This paper studies two stage flowshop scheduling with availability constraints. There are two machines, an upstream machine M1 and a downstream machine M2. Each machine may have one or more unavailable intervals. There are n jobs, denoted as Ji, $1 \leq i \leq n$. Each job Ji, $1 \leq i \leq n$, has two operations ai and bi which have to be processed on machine M1 and on M2, respectively. The operation bi cannot start on machine M2 before ai finishes on M1. We want to find a schedule of the jobs so that the total completion time is minimized. The problem is NP-hard in the strong sense even if both machines are always available, so we assume there is only one unavailable interval, either on M1, or M2. We focus on optimal solutions for special cases and good heuristics for general case. We first study some special cases and give some theoretical results. Then through numerical study, we investigate the performance of various existing heuristics when the machine availability constraint is present.

■ MB78

S- Greenwood

Incentives and Teamwork in R&D

Emerging Topic: New Product Development

Emerging Topic Session

Chair: Anant Mishra, Carlson School of Management, University of Minnesota, Minneapolis, MN, 55455, United States

1 - Team Collaboration in Innovation Contests

Sidika Tunc, University College London, London, United Kingdom, C. Gizem Korpeoglu, Christopher S. Tang

An innovation-contest organizer posts a problem to agents who can submit their solutions as individuals or teams. We show that agents may benefit from collaborating as teams if they are less likely to conform each other and if the organizer's problem requires indivisible tasks. Also, the organizer may benefit from this collaboration if he runs a contest on a platform to obtain high-novelty solutions or low-novelty solutions that require highly divisible tasks. If the organizer runs a contest internally to obtain low-novelty solutions that require divisible tasks, he may also benefit from it.

2 - Backers or Socializers? Alternative Mechanisms for Learning by Co-creation

Berke Emre Guzelsu, Boston University, 595 Commonwealth Avenue, Boston, MA, 02215, United States, bguzelsu@bu.edu, Nitin R. Joglekar

Learning based on knowledge and financial input from customers is an emergent co-creation phenomena. A Transactive Memory System (TMS) is a mechanism through which groups collectively encode, store, and retrieve knowledge. We extend TMS by conducting an intermediate theory building exercise using data from the tabletop gaming industry. Our data accounts for Kickstarter backers, that represent the crowdfunding channel, and Discord threads that represent a social media channel for socializers. We contrast alternative TMS learning mechanisms for backers and socializers. Results yield new constructs and novel linkages of these constructs to characterize learning via co-creation.

3 - Set Asides for Small Businesses in Public Sector Procurement: Evidence from US Federal Government R&D Contracts

Dwaipayan Roy, Carlson School of Management, University of Minnesota, Minneapolis, MN, United States, royxx298@umn.edu, Anant Mishra, Kingshuk K. Sinha

This paper investigates the performance outcomes of R&D contracts that have been awarded preferentially to small businesses by the US Federal Government. Specifically, we examine how the contract pricing type and contractor experience influences the relationship between the Set-Asides status of a contract and its performance outcome.

4 - Incentive Design and Equity Contracting in Startup Teams

Evgeny Kagan, Johns Hopkins University, Baltimore/Washington DC, MD, United States, ekagan@jhu.edu, Stephen Leider, William S. Lovejoy

This paper examines the effects of equity contracts on effort and value generation in startup teams.

■ MB79

S- Issaquah A

Joint Session Agriculture/Practice Curated: Prediction and Decision Models for Agricultural Seed Development

Emerging Topic: Agriculture

Emerging Topic Session

Chair: Dieter Armbruster, Arizona State University, Tempe, AZ, 85287-1804, United States

Co-Chair: Esma S Gel, Arizona State University, Tempe, AZ, 85287-8809, United States

1 - Optimize Training Data for Genomic Prediction

Christopher J. Basten, Science Fellow, Syngenta, Durham, NC, United States, christopher.basten@syngenta.com, Zhigang Guo

Genomic prediction utilizes joint marker and phenotypic data to form a training dataset and construct predictive models for inbred lines and hybrids. Predictions are on the genotypes of individuals that are genotyped but not phenotyped. Specifically, we will focus on a method known as GBLUP (genomic best linear unbiased predictor). Current datasets are testing the limits of GBLUP with respect to computational feasibility, time and expense. One major area of interest is how to trim training data sets to a reasonable size and still maintain predictive accuracy and power.

2 - Multi-task Learning for Asset Allocation

Wenjun Zhou, University of Tennessee Knoxville, 916 Volunteer Boulevard, SMC 247, UT BAS, Knoxville, TN, 37996, United States

Sellers of crop seeds need to plan for the variety and quantity of seeds to stock at least a year in advance. There are a large number of seed varieties of one crop, each can perform best under different growing conditions. Given the unpredictability of weather, farmers need to make decisions that balance high yield and low risk. In this study, we propose a data-driven approach for selecting a portfolio of seed varieties that integrates the predictive and the prescriptive steps.

3 - Quantitative Modeling and Analysis of Trial Data for Variety Advancement Decisions

Esma S. Gel, Arizona State University, School of Computing, Informatics and, Decision Systems Engineering, Tempe, AZ, 85287-8809, United States, esma.gel@asu.edu, Dieter Armbruster, Greg Doonan

Global food security depends strongly on sustaining the unprecedented growth in crop yields that has been observed over the past 70 years. A major enabler of increased crop yields (e.g., bushels per acre) has been due to the biological innovation (hybrid crops, biotechnology) that has been involved in the identification and development of new varieties for a number of major crops. The agricultural seed development process is performed through testing the varieties over multiple years, in multiple locations and climates. We consider prediction, visualization and optimization approaches to improve the performance of seed advancement decisions in partnership with a major seed manufacturer.

4 - Planning and Coordination Tools for the Insertion of Small Farmers into Rapid-response Fresh Food Supply Chains

J. Rene Villalobos, Arizona State University, Tempe, AZ, 85287, United States, Rodrigo Ulloa, Hector Flores

In this presentation, we introduce a supply chain integrated planning and coordination environment that includes information acquisition and coordination supply-demand tools to close the logistics and information gap between small growers of fresh fruits and vegetables and existing and emerging markets, especially those created by direct sales to consumers through ecommerce. In particular, we discuss some of the analytical tools being used to achieve a better coordination between the demand and the supply of highly perishable crops.

■ MB80

S- Issaquah B

Joint Session TIME/Practice Curated: Empirical Research in Innovation and Entrepreneurship II

Sponsored: Technology, Innovation Management & Entrepreneurship

Sponsored Session

Chair: Tian Chan, Emory University's Goizueta Business School, Atlanta, GA, 30322, United States

1 - Process Innovation in Pharmaceutical Industry

Ivan Lugovoi, HEC Paris, 1 Square Theodore Judlin, Jouy-en-Josas, 75015, France, ivan.lugovoi@hec.edu, Dimitrios Andritsos, Claire Senot

Through a collaboration with expert patent attorneys we construct a unique dataset that: i) evaluates process innovation through a detailed observation of pharmaceutical manufacturers' portfolios of process patents and ii) measures key qualitative dimensions of process innovation, such as novelty, scope of protection and locus of application. We find a positive association between overall process innovation and firm performance. When differentiating between dimensions of process innovation, results further suggest that high novelty is beneficial, and complemented by a broad scope, but only for patents applying to the later phase of the manufacturing process.

2 - Best in Class: The Effect of Relative Perceived Quality on Demand in the U.S. Automobile Industry

Hallie Cho, INSEAD, PhD Office, Singapore, 138676 features, Singapore

Based on co-occurring product mentions in online customer reviews, we find which products are perceived similarly in the context of the U.S. automobile industry. We use aggregate customer review measures as a proxy for product quality to investigate how relative perceived quality amongst similar products influences market shares in a competitive market. We also develop a uniqueness index of product to examine what drives the difference in perceptions. Our findings help to understand the optimal distinctiveness from the consumer's perspective and have important implications for an automobile manufacturer's product differentiation strategy.

3 - Patent Grant Delays and Future Innovative Activities

Param Pal Singh Chhabra, Grad Student, Georgia Tech, Atlanta, GA, 30308, United States, param.chhabra@scheller.gatech.edu, Manpreet Singh Hora, Karthik Ramachandran

Patent grant delays have the potential of negatively affecting future patenting activities of inventors. Utilizing patents application data, spanning more than three decades, published by the USPTO, we verify this negative relationship. Additionally, we find that the delays not only affect the quantity but also the quality of the patents. Inventors also diversify their patents portfolio in pursuit of the fast track domains.

4 - Project Selection and Competitive Signals: Insights from Drug Development

Panos Markou, UVA Darden Business School, Charlottesville, VA, CB2 1AG, United States, markoup@darden.virginia.edu, Stylianos Kavadias, Nektarios Oraiopoulos

Selecting the right R&D projects is challenging because of the uncertainty and complexity inherent in making such decisions. We leverage a unique database comprising the development pipelines of the Top 15 pharma firms to examine how signals from competitive projects drive the selection decision. Early-stage competitive projects decrease the likelihood of the firm selecting to compete in the same domain, whereas late-stage projects signal high technological feasibility and increase this likelihood. These effects are moderated by the relatedness of the underlying technologies and market potential. Finally, we provide evidence on how such selection meaningfully contributes to productivity.

■ MB81

S- Kirkland

Supply Chain Optimization Models for Petrochemicals

Sponsored: Energy, Natural Res & the Environment/Natural Resources Petrochemicals

Sponsored Session

Chair: Said Rahal, University of Alberta, AB, Canada

1 - Challenges in Multilevel Supply Chain Optimization

Braulio Brunaud, Data Science Lead, Johnson & Johnson, Bridgewater, NJ, United States, BBrunau1@its.jnj.com, Satyajith Amaran, John M. Wassick, Ignacio E. Grossmann

Supply chain decisions are hierarchically organized in strategic, tactical, and operational decisions. In practice, these planning processes are conducted independently with minimal feedback, leading to suboptimal solutions. There is a large hidden benefit in integrating these decision-making processes. This challenge is usually approached by standardizing the data systems first with the hope to optimize in the future. In this seminar, we discuss an alternative modular approach that does not require data standardization, in which each decision-making process is encapsulated identifying the transfers of information. We apply this framework to the integration of planning and scheduling.

2 - Proactive and Reactive Scheduling for the Steelmaking and Continuous Casting Process under Uncertainty via Adaptive Robust Optimization

Said Rahal, PhD Candidate, University of Alberta, Edmonton, AB, Canada, rahal1@ualberta.ca, Zukui Li

The schedule of a steel-making and continuous-casting process defines the unit assignments of molten steel, their sequence and their start and finish processing time in each unit. These decisions have to meet strict production requirements in spite of the uncertain processing time. In this work, we discuss robust-proactive and deterministic-reactive scheduling methods. We show the significance of computing ``here and now” decisions which are immune to small disruptions. For larger magnitudes, a robust proactive hybrid method is devised that combines the fortes of the previous two methods.

3 - A Static Transshipment Model for Crude Oil Logistics Planning at a Petroleum Company

Badri Toppur, Rajalakshmi School of Business, Chennai, India, badri.toppur@rsb.edu.in

As an aspect of implementing their operations strategy and planning, a petroleum company faces the complex problem of procuring crude oil from suppliers in Persian Gulf, West Africa, North Africa, West Asia, Bombay High, India, and USA. The crude oil is shipped to two ports in Gujarat by tankers and other vessels. From these two ports the crude oil is moved to three refineries, pumped via pipelines or transported by the railroad lines. Instead of demand, the refineries have known capacity, that are different for two types of crude oil. We have modelled the problem as a static transshipment network, and used an LP solver to obtain an optimal solution. Sensitivity analysis shows that the solution is stable.

■ MB82

S- Leschi

Sustainable and Responsible Supply Chain Management

Sponsored: Energy, Natural Res & the Environment/Environment & Sustainability

Sponsored Session

Chair: Jose Cruz, University of Connecticut, Hartford, CT, 06103, United States

1 - Sustainable Supply Chain Management with Environmental Tax Policies

Min Yu, University of Portland, Pamplin School of Business, Portland, OR, 97203, United States, Jose Cruz, Dong Li, Amir H. Masoumi

We develop a multiperiod model to study the firm’s long-term investment strategy on sustainable energy-efficient technologies to take advantage of tax incentives while maximizing the net present value of the investment. We also investigate the impacts of different environmental tax policies on equilibrium product demands, prices, total emissions, and investment strategies on sustainable technologies.

2 - Sustainable Supply Chain Network Model Through Reduction in Pollution Stock

Sara Saberi, Worcester Polytechnic Institute (WPI), Foisie School of Business, Worcester, MA, 01609, United States, ssaberi@wpi.edu

This study presents a multiperiod, multitier, sustainable supply chain with freight carriers network model to address such concerns. The model comprises manufacturers, retailers, and carriers engaged in a dynamic, noncooperative game. It considers the longitudinal accumulation of pollution stock, pollution absorbtion by nature, and mitigation actions. The study examines numerical examples with an analysis of the effect of different tax rates on production, transportation, sales, and levels of pollution stock and mitigation efforts. The outcome presents important strategic reactions of decision makers to tax policies.

3 - The Interaction of Forward and Reverse Logistics

Qiang Qiang, Penn State, Management Division, Malvern, PA, 19355, United States, qzq10@psu.edu, Rong Fu

In this paper, we analyze the interaction of two supply chain networks. The product of the forward supply chain is recycled and treated as the input of the reverse supply chain. Theoretical and computational results are discussed, which are illustrated by numerical results.

4 - Corporate Social and Environmental Sustainability: A Multiperiod Supply Chain Integration and Economic Framework

Jose Cruz, University of Connecticut, 100 Constitution Plaza, Hartford, CT, 06103, United States, jose.m.cruz@uconn.edu

We analyze the effects of social and environmental sustainability activities on multiperiod supply chain network economic sustainability. Suppliers, manufacturers, and retailers decide about their production and transaction quantities as well as the level of investment on social and environmental sustainability they want to pursue to maximize net return and minimize their externality risk/cost over the multiperiod planning horizon. The results show that high levels of sustainability can lead to the lower overall cost and therefore, lower prices and higher product transaction.

■ MB83

S- Medina

Handling Uncertainty in Power System Operations

Sponsored: Energy, Natural Res & the Environment/Electricity

Sponsored Session

Chair: Evangelia Spyrou, Johns Hopkins University, Baltimore, MD, 21218, United States

1 - The Parametric Cost Function Approximation for Practical Stochastic Optimization in Energy

Warren B. Powell, Princeton University, Dept of Operations Research and Financial Eng, Princeton, NJ, 08544, United States, powell@princeton.edu, Saeed Ghadimi, Hugo P. Simao

There has been a widespread misconception that the way to handle uncertainty in planning problems in energy is through dynamic programming or stochastic programming. For problems that require planning into the future, these methods overlook a powerful strategy, widely used in industry which we call the parametric cost function approximation (CFA) approach. This involves solving a parametrically modified approximation (such as a deterministic lookahead), where tunable parameters have to be optimized to produce robust solutions. We formalize this approach, and describe the challenges of forming and tuning parametric CFAs, which closely parallel similar problems in online machine learning.

2 - Dealing with Wind Uncertainty in Two-settlement Electricity Markets: A PJM Case Study

Ali Daraeepour, Postdoctoral Research Associate, Andlinger Center for Energy and Environment, Princeton, NJ, United States, a.daraeepour@princeton.edu, Dalia Patino-Echeverri, Antonio J. Conejo

The economic efficiency of power systems where wind energy represents a large share of generation, improves by considering an explicit characterization of wind uncertainty into the electricity market clearing process. This study estimates the economic and environmental efficiency gains achieved by using stochastic commitment and dispatch programming approaches for dealing with wind uncertainty. It also proposes second best deterministic methods that achieve up to 60% of the efficiency enhancement gained by the stochastic ones. A simulation of a system representative of PJM's resource mix is used to quantify the differences between the stochastic and proposed deterministic methods.

3 - Dynamic Dimensioning Approach for Operating Reserves: Proof of Concept in Belgium

Anthony Papavasiliou, CORE, UCLouvain, Voie du Roman Pays 34, L1.03.01, Louvain la Neuve, 1348, Belgium, anthony.papavasiliou@uclouvain.be, Kristof De Vos, Nicolas Stevens, Olivier Devolder, James Matthys-Donnadieu

We present a new method for the sizing of operating reserves. The talk revisits the current static sizing method applied in Belgium, which determines the required capacity once a year. The presented dynamic sizing method determines the required capacity on a daily basis, using the estimated probability of facing a system imbalance during the next day. This risk is estimated based on historical observations of system conditions by means of machine learning algorithms. A proof of concept is presented for the Belgian system. The implementation of the method is underway by ELIA, the Belgian TSO.

4 - The Value of Probabilistic Forecasts for Sizing Flexible Ramping Products: A CAISO Case Study

Evangelia Spyrou, National Renewable Energy Laboratory, Geography and Environmental Engineer, Golden, CO, 21218, United States, elina.spirou@gmail.com, Venkat Krishnan, Benjamin Field Hobbs, Qingyu Xu, Jie Zhang, Binghui Li, Rui Zhang

Flexible ramping products help Independent System Operators (ISOs) manage uncertainty and variability. Currently, US ISOs estimate net load uncertainty through statistical analysis of historical forecast errors. Existing approaches fail to see the impact of real-time weather information on the magnitude of the uncertainty. Here, we present how advanced probabilistic forecasts of solar radiance can inform ISO's estimates of uncertainty. We compare the suggested approach to current ISO practice and analyze the economic and reliability benefits for a 118-bus system mimicking CAISO.

■ MB84

S- Ravenna A

Battery Energy Storage in Long-Term Energy-Economy Planning Models

Sponsored: Energy, Natural Res & the Environment/Energy Sponsored Session

Chair: Cara Marcy, U.S. Environmental Protection Agency, United States Energy Information Administration, Washington, DC, 20585, United States

1 - Firm Capacity from Battery Storage in Long-term Planning Models

Wesley Cole, National Renewable Energy Laboratory, Golden, CO, United States, wesley.cole@nrel.gov

Long-term models of the electricity sector aim to ensure resource adequacy for the buildouts considered in the models. This presentation will consider how battery storage, which is energy limited according to its duration, can contribute toward the firm capacity requirement in long-term planning models, with a specific look at the ReEDS model.

2 - Evaluating the Emissions Impact of Utility-scale Battery Storage: Investment Versus Dispatch

Ryan Sims, U.S. Environmental Protection Agency, Washington, DC, United States, Sims.Ryan@epa.gov

Spurred by improving costs and growing regulatory support, the pace and scale of new battery storage installations to support power system operations have accelerated in recent years. This presentation utilizes the U.S. Environmental Protection Agency's Integrated Planning Model to evaluate the emissions impact of new, four-hour battery storage on the grid, with an emphasis on understanding how various levels of storage penetration alter the economic landscape for new investment.

3 - Capturing the Value of Storage in Generation Capacity Expansion Models

David Young, Electric Power Research Institute, Palo Alto, CA, United States, dyoung@epri.com, John Erik Bistline

We add a representation of battery storage to an 8760 hour static equilibrium electric sector model with endogenous capacity rental and dispatch across interconnected regions. We apply this framework to study how the energy arbitrage and capacity values of storage vary across a range of sensitivity scenarios and draw some inferences as to how the results might change with lower temporal resolution - a common assumption among long-term capacity expansion models. We find that magnitudes of energy and capacity revenues vary by region and scenario, that both are required for properly valuing storage, and argue that lower temporal resolution can mis-represent the relative value streams.

4 - Modeling Battery Storage in EIA's National Energy Modelling System (NEMS)

Chris Namovicz, Team Lead for Renewable Electricity Analysis, U.S. Energy Information Administration, Washington, DC, United States, chris.namovicz@eia.gov, Manussawee Sukunta, Vikram Linga

Over the past several years, EIA has incorporated energy storage into it National Energy Modeling System (NEMS), addressing challenges including representing serial charge/discharge; the diurnal value of variable renewables; and value toward meeting reserve margins. This paper will address public presentation and interpretation of the energy storage model results, in particular assessment of the competitiveness of storage compared to conventional resources using levelized cost and levelized value metrics derived from model results to develop a proposed levelized cost of storage metric.

■ MB85

S- Ravenna B

Telecommunications and Network Analytics Best Paper Award

Sponsored: Telecommunications and Network Analytics Sponsored Session

Chair: Luis Gouveia, University of Lisbon, Lisbon, 1749-016, Portugal

1 - Regenerator Location Problem in Flexible Optical Networks

Baris Yildiz, Koc University, Koc University IE Department, Rumelifeneri Yolu, Istanbul, Turkey

2 - Power and Channel Allocation for Non-Orthogonal Multiple Access in 5G Systems: Tractability and Computation

D.Y. Lei Lei, University of Luxembourg, Luxembourg, Luxembourg

3 - Optimizing Flow Thinning Protection in Multicommodity Networks with Variable Link Capacity

Michal Pioro, Warsaw University of Technology, Warsaw, Poland

4 - An Inexact Sample Average Approximation Approach for the Stochastic Connected Facility Location Problem

M. Gisela Bardossy, University of Baltimore, Baltimore, MD, 21201, United States

■ MB86

S- Ravenna C

The Role of Demand Response in Managing Future Electricity Loads

Sponsored: Energy, Natural Res & the Environment/Energy Sponsored Session

Chair: Nils Johnson, PhD, Electric Power Research Institute, Palo Alto, CA, United States

1 - Potential Roles for Demand Response in More-electrified Futures

Elaine Thompson Hale, National Renewable Energy Laboratory, National Renewable Energy Laboratory, Golden, CO, 80401, United States, elaine.hale@nrel.gov

Power systems, both supply- and demand-side, are rapidly evolving due to technological change and various policy goals. This talk will describe potential roles for demand response in future power systems serving more electrified loads (including transport) and with higher shares of variable renewable generation. Starting from a broad definition of demand response as any change imposed on demand-side end-use operations meant to support power grid functionalities, we draw on a number of past and ongoing research topics to provide insight into the value of different kinds of demand response in different kinds of power systems.

2 - The Implications of Coordinated Electric Vehicle Charging for Power Supply

Nils Johnson, Senior Technical Leader, Electric Power Research Institute, Palo Alto, CA, 94025, United States

Depending on when electric vehicles (EVs) are charged, large-scale adoption of EVs will likely increase electricity demand and may have significant impacts on future load shapes. This analysis uses an integrated electricity demand and supply model, US-REGEN, to explore the load implications of large-scale EV deployment and to examine the potential impacts of vehicle charging on the US electricity supply system through 2050. A scenario approach is used to explore the implications of uncoordinated versus coordinated vehicle charging for capacity requirements, plant utilization, and electricity prices.

3 - California Optimal Grid Operation for a High Renewable Electricity Supply System: Future Role of Electric Vehicles

Behdad Kiani, PhD, University of California-Davis, Davis, CA, United States

A mathematical optimization model is introduced to optimize the grid interaction of electric vehicles in long term electricity planning towards high renewable supply system. Optimal vehicle-to-grid (V2G) and grid-to-vehicle (G2V) energy flows are calculated based on various factors, such as battery capacity, charging and discharging rates, required energy for driving demand, hourly electricity price, and ramp-up constraints. We assume a ramp-up of VRE to 60% of all electricity generation by 2030 and 100% by 2050, with a similar increase in the EV share of new LDV sales, creating a significant stock (about 7 million) by 2030 and nearly complete transition (to over 20 million vehicles) by 2050.

4 - Quantifying the Benefits of Imperfect Demand Response

Patricia J. Levi, PhD Candidate, Stanford University, Palo Alto, CA, United States

Demand Response (DR) could help integrate renewables into the electricity grid by making electricity demand more flexible. However, it has unique restrictions on its usage. This study identifies the impact of several types of usage and advance-notification constraints on the system-wide value of DR. A unit commitment model based on ERCOT's wholesale market is used. DR representation is based off of current incorporations of DR into existing wholesale markets across the US. Results suggest which characteristics of DR may lead to greater system value and explore how DR should be represented in wholesale markets to respect customer preferences.

■ MB92

S- Grand Ballroom A

Supply Chain Management VI

Contributed Session

Chair: Daniel Nielubowicz, Clemson University, Central, SC, 29630, United States

1 - Proposal of Coordinated Trading System for Eliminating Double Marginalization

Sidi WU, Waseda University, Tokyo, Japan, sidiwu@gmail.com, Jiahua WENG, Seung-Jin Ryu

Double marginalization occurs while an upstream company and a downstream company negotiating their transaction price and quantity only in consideration of their own profit. As a result, total profit of the supply chain is usually lower than the exclusive profit of one company. In this study, we focus on the negotiation between a manufacturer and a mass retailer. A coordinated trading system with information estimation and negotiation guide function is proposed to make the manufacturer and the retailer realize win-win relationship. Mitigation effects on the whole supply chain profit are shown in the experiment results. The profit allocation is also to be discussed in this study.

2 - Understanding the Impact of Partner Trust Level on Supply Chain Surplus

Seong-Hyun Nam, Professor, University of North Dakota, Grand Forks, ND, United States, snam@business.und.edu

Trust-based collaboration is viewed as one of the most critical factors in achieving effective and efficient forecasting performance in a supply chain. Research indicates that the willingness to cooperate and share forecast information with a certain level of partner trust can create mutual competitive advantage throughout the supply chain networks. The efforts to shift the business relationship to a certain level of trust, however, may incur operational costs including additional investments in developing trust. This paper examines how partner trust can improve demand forecast accuracy and develops a decision-making model for trust-level optimization that can promote supply chain surplus.

3 - An Investigation of SaaS Adoption W/in the Supply Chain

John F. Kros, Vincent K. McMahon Distinguished Professor, East Carolina University, Greenville, NC, United States, krosj@ecu.edu

This research investigates the adoption or non-adoption of Software as a Service (SaaS) within the supply chain. Survey data will be used to discuss why/how/when/what supply chain professionals are adopting when it comes to transportation management systems (TMS), warehouse management systems (WMS), yard management systems (YMS), etc.

4 - Measuring Supply-chain Performance for Strategic Management and Managerial Control

Anthony Gerard Vatterott, University of Missouri-Saint Louis, Saint Louis, MO, United States, anthonygvatterott@gmail.com, Wesley Boyce, Laurence Douglas Smith

Supply-chain engineering and management require an understanding of interrelationships among supply-chain metrics, strategic business principles and the foci of supply-chain managers as they pursue superior supply-chain performance. With data from an extensive review of supply chain metrics proposed in the literature, we use text analytics to demonstrate these interrelationships. Then we discuss how strategies for containing risk while maximizing supply-chain performance may be embedded in optimizing models for supply-chain management.

5 - The Impact of Blockchain Technology within SCOM: An Event Study

Daniel Nielubowicz, Clemson University, Central, SC, United States, dnielub@g.clemson.edu, Aleda Roth

Blockchains are perceived as key to solving industry issues around accountability, traceability and transparency. We utilize company announcements to illustrate the key drivers of blockchain adoption and its effects on the supply chain.

6 - Dynamic Consolidation of Picked Orders in an Online Orders Fulfillment Warehouse

Wen Zhu, New Jersey Institute of Technology, Newark, NJ, United States, wz83@njit.edu, Sanchoy Das

Order fulfillment warehouses (F-Warehouses) are a critical component of the physical internet behind online retail supply chains. Items are stocked in multiple random locations dispersed throughout the F-warehouse. Orders are then picked and collected in totes which are assigned to one of many packaging stations. The F-Warehouse is continuously generating totes. Each multi-item order is therefore located in several totes and must be consolidated. This research formulates and solves the order consolidation problem. We formulate the problem a MIP and present a fast heuristic solution.

■ MB93

S- Grand Ballroom B

Information Systems III

Contributed Session

Chair: Rafat Elsharef, UW-Milwaukee, Milwaukee, WI, 53211, United States

1 - Data Compression with Attribute Homomorphism in Information Systems

Yanbin Hao, Northwestern Polytechnical University, Xi'an, China, nwpuhyb@163.com

Data compression is an important topic in data processing and homomorphism is considered as an effective tool for data compression. This paper defined the attribute isomorphism and attribute homomorphism for information system based on the functional dependency relation over attributes. It then investigated major properties of the attribute homomorphism. By using the attribute equivalence to acquire the deal homomorphism, it achieved lossless compression for information system. Finally, this paper provided a method to measure the ideal level of any attribute homomorphism by comparing distance between the original system and the image information system.

2 - Security-sensitive vs. Security-general: A Study of Information Security Decision under Security Externality

Yong Wu, Glorious Sun School of Business & Management, Donghua University, Shanghai, China, wuyong1202@sina.com

Information security incidents leading to firms suffer the loss of information assets have been occurring on a regular basis. The goal of security investment for security-sensitive firms is to improve the survival probability as high as possible, while that for security-general firms is to reduce the security loss as far as possible. This paper examines how security-sensitive firms differ in timing of security investment from security-general firms, characterizing how asset uncertainty, security externality, and environment riskiness influence both security quality and investment timing.

3 - Examining Technostress on Employees' Security-related Behaviors

Forough Nasirpouri Shadbad, Oklahoma State University, Stillwater, OK, United States, David Biros, Madhav Sharma

The behavioral information security literature depicts employees as a major information security threat in organizations. To explore how employees' interaction with IT increases security vulnerabilities, we utilize the technostress literature. Although, technostress studies have examined the effect of stressors on employees' performance, its effect on security-related behaviors is unclear. To this end, we examine the effect of IT stressors on individuals' information security behaviors through their responses to the stressors (strain). Using SEM to test the proposed model, we expect individuals with high of perceptions of stressors are more likely to engage in security violations.

4 - Cyber Security for Industrial Control Systems: Evaluation and Recommendations

Rafat Elsharef, PhD Student and lecturer, UW-Milwaukee, Milwaukee, WI, United States, elsharef@uwm.edu, Wilkistar Otieno

There is a great demand to connect ICS and SCADA systems to the internet for monitoring, control, and data gathering, by doing so, we exposing these critical devices to the internet which will increase the probability of security threat and risk against these critical devices. This presentation will cover best practices and security recommendations as we are connecting these devices to the internet. Current popular protocols will be discussed. Real hacked cases with lessons, recommendations and security measures to prevent such hacks will be addressed. Wireshark analysis of captured data will be analyzed to show vulnerabilities of such devices.

■ MB94

S- Grand Ballroom C

Industry Job Search Panel

Emerging Topic Session

Chair: Warren Hearnes, Cardlytics, Lilburn, GA, 30047-7417, United States

1 - Industry Job Search Panel

Warren Hearnes, Cardlytics, Lilburn, GA, 30047-7417, United States

This panel discusses the industry interview process and do's and don'ts associated with the job search. In addition to comment from current and former recruiters, time will be provided for questions and answers.

Panelists

- Mark A. Gallagher, Air Force Institute of Technology, Columbus, OH, 43229-5535, United States
- Nabil A. Raad, Ford, Bloomfield, MI, 48301, United States
- Abelardo Mayoral Fierros, Fraser Health Authority, Surrey, BC, Canada
- Russ Philbrick, President, Polaris Systems Optimization, Seattle, WA, United States
- Anne G. Robinson, Kinaxis, Basking Ridge, NJ, 07920, United States
- Je Sang Sung, BNSF Railway, Fort Worth, TX, 76118, United States
- Kathryn Walter, ORTEC, Houston, TX, United States

■ MB95

S- Grand Ballroom D

Inclusion within INFORMS

Sponsored: Diversity, Equity, and Inclusion

Sponsored Session

Moderator

Christopher S. Tang, University of California-Los Angeles, UCLA Anderson School of Management, Operations and Technology Management, Los Angeles, CA, 90095-1481, United States

We explore the issue of "inclusion" of all INFORMS members in the context of gender, race, sexual orientation, etc. We also discuss the issue of connecting INFORMS members from different schools (Business Schools, IE/OR departments, and OR/MS related departments), different geographical regions (US vs. International), etc.

Panelists

- Brian T. Denton, University of Michigan, University of Michigan, Ann Arbor, MI, 48109-2117, United States
- Beril L. Toktay, Georgia Institute of Technology, College of Management, Atlanta, GA, 30308, United States
- Michael P. Johnson, University of Massachusetts Boston, Department of Public Policy & Public Aff, Boston, MA, 02125-3393, United States

Monday, 12:30PM - 2:30PM

■ Poster Competition

CC-Exhibit Hall, Level 4

Monday Poster Competition

Competition Poster Session

1 - Approximation Algorithms of Maximum Entropy Sampling Problem

Yongchun Li, Virginia Tech, Blacksburg, VA, United States, liyc@vt.edu, Weijun Xie

This paper studies the maximum entropy sampling problem (MESP), which selects the most informative principal submatrix of a given size from a positive semidefinite matrix. We first derive a new convex integer programming formulation for MESP. Using the convex relaxation solution, we propose a sampling algorithm and its deterministic implementation, which improves the best known approximation bound. We also analyze the widely used local search algorithm for MESP and prove its first known approximation bound. Finally, we extend our analysis to A-optimality.

2 - Efficient Algorithms for Discrete Distributionally Robust 2-stage Stochastic Program

Zhe Zhang, Georgia Tech, Atlanta, GA, United States, zzhang724@gatech.edu, Shabbir Ahmed, Guanghui Lan

Recently, there has been a growing interest in distributionally robust optimization because of data-driven optimization. However, very few efficient algorithms have been developed, and most of them cannot handle the non-smoothness of the second stage cost effectively and tend to scale poorly with the usually large number of scenarios K. In this paper, we fill the gap by developing two accelerated algorithms whose iteration complexity only mildly depend on K for solving distributionally robust two-stage stochastic optimization problems with different ambiguity set. Moreover, the major computations involved in each iteration of these algorithms can be conducted in parallel if necessary.

3 - Development of an Interactive Visualization for Best Transport Scenario to Optimize Outcomes for Stroke Patients Using a Statistical Probability Model

Noreen Kamal, Assistant Professor, Dalhousie University, Halifax, NS, Canada, Noreen.Kamal@dal.ca, Kimberly K. Chan, Michael J. Francis, Jessalyn Holodinsky

Endovascular treatment (EVT) for ischemic stroke is a new treatment that is only available at urban tertiary hospitals; it is given with a medical treatment that is widely available. There is uncertainty on the best transportation scenario. Is it better to transport to the closest hospital and receive medical treatment early and then transfer for EVT or bypass this hospital to receive both treatments at the tertiary hospital? A mathematical model was developed incorporating variables that effect patient outcomes using data from clinical trials. The model was the basis for the development of a cloud software showing the best transport scenario through interactive maps to assist with decision making.

4 - A Novel Positive Transfer Learning (posTL) Approach for Telemonitoring of Parkinson's Disease

Hyunsoo Yoon, Postdoctoral Scholar, Arizona State University, Tempe, AZ, United States, hyoon15@asu.edu, Jing Li

Telemonitoring of voice signals of Parkinson's Disease (PD) patients using an At-Home Testing Device is a cost-effective logistically-convenient way to monitor disease progression and optimize treatment. Key challenges in telemonitoring are patient heterogeneity and limited data for each patient. We propose a transfer learning approach, PTL, which can leverage other patients' information when building a predictive model for a target patient. The unique features of PTL include intelligent selection of patients to transfer to avoid negative transfer and maintain patient privacy preservation.

5 - An in Depth Look on the Effect of Abortion Policy in Alabama with System Dynamic Modeling

Yi Ling Chang, Claremont Graduate University, Newport Beach, CA, United States, yi-ling.chang@cgu.edu, Yuan-Yuan Lee

A debate has recently ensued when Alabama signed a state-level legislation restricting access towards abortion. This research adopts system dynamic modeling to demonstrate the complex government expenditure budget and further illustrates the effects abortion restriction has on welfare budget coping the contemporary issues with teenage pregnancy and prenatal detection of transmittable diseases.

6 - Home Bias in Non-profit Online Lending: A Perspective of Social Identity Theory

Yingli Gong, Tongji University, Shanghai, China, 1630977@tongji.edu.cn, Hongwei Wang

As a crucial factor affecting individual preference and even economic decision-making in experimental economics, social identity is a persuasive perspective to reveal the home bias in online lending. Using the data from a non-profitable online lending platform and employing logistic regression model, we find that regional identify can promote lender's lending behavior: borrowers and lenders from the same country or closer are more willing to trade. The closer the geographical distance is, the higher the financing rate is, and the higher the average financing amount is. Our study identifies that regional identity exists and introduces social identity into online lending.

7 - Dynamic Pricing Solves the Urban Transportation Disparity - Evidence from NYC On-demand Ride-sharing Drivers

Qing Wei, Clemson Univeristy, Fargo, ND, United States, qwei@clemson.edu

We investigate the effect of dynamic pricing on ride-sharing drivers' supply. Instead of the hour and wage relation explored by previous literature, we look at the instantaneous response of drivers to price surges. Using data from NYC, we estimate the structural model through a constrained non-parametric approach. We find that dynamic pricing effectively solves the geographical disparity problem of the taxi, it increases the overall accessibility and quantity of pickup service. Without dynamic pricing, in our counterfactual case, platform drivers will be clumped in Manhattan and airports as taxi drivers. And 27 % of the total supply will be lost, with a tremendous 59% drop in the non-Manhattan area.

8 - Does Shopping Behavior Impact Food Waste

Alwin Dsouza, Arizona State University, Mesa, AZ, United States, adsouza3@asu.edu

Significant food waste by households particularly in developed countries has gathered attention recently. Food waste happens when households are not able to match their purchases and consumption. In our study, we intend to measure the magnitude of food waste across online, mixed and offline shoppers. There are two opposing factors playing here. Online shoppers are more inclined to follow the shopping list which may reduce food waste, but online shoppers need to pay for delivery costs and follow a minimum basket size, which may increase the food waste. The net impact is inconclusive. We will be using scanner data to test the hypothesis. We focus on shoppers learning behavior to measure food waste.

9 - Biofuel Supply Chain Optimization Considering Economic and Environmental Aspects Using a Genetic Algorithm

Juan V. Fernandez, The University of Texas at El Paso, El Paso, TX, United States, Heidi A. Taboada, Jose F. Espiritu

Biofuel production has been identified as an alternative source to mitigate greenhouse gas emissions, reduce dependence on fossil fuels, and to alleviate increase in energy demand. The growing demand of biofuel production has prompt the need for efficient and sustainable biofuel supply chain networks. The following paper presents a multiple objective genetic algorithm considering the simultaneous optimization of economic and environmental objectives. Furthermore, the model determines harvested and purchased biomass units, as well as the openings of intermediate warehouses and the transportation flows.

10 - Efficient Trust Region Methods for Inverse Mixed Integer Optimization

Ian Yihang Zhu, University of Toronto, Toronto, ON, Canada, i.zhu@mail.utoronto.ca

We study inverse mixed integer linear optimization (inverse MILP) problems, which seek to infer the unobserved objective function of an optimization problem (a forward MILP problem) using a solution of this problem. The standard solution method is a cutting-plane algorithm which requires solving the forward problem numerous times in order to add cuts. We propose a trust region method in which we can generate cuts within a restricted feasible space of the forward problem. We show using MIPLIB instances that our approach significantly reduces both the computational complexity of obtaining each cut as well as the number of cuts required until the optimal solution to the inverse problem is obtained.

11 - Fast Security-constrained Optimal Power Flow for Application in Flow Based Market Coupling

Richard Weinhold, Technische Universität Berlin, Berlin, Germany, Robert Mieth

Power flows and thus electricity market outcomes are constrained by physical transmission system constraints and its security requirements such as the N-1 criterion. Internalization of this criterion in optimal power flow (OPF) analyses often leads to prohibitive computational complexity even for linearized (DC) power flow equations. We present a methodology to obtain a minimal set of linear constraints that yields an exact N-1 secure DC-OPF solution that can be leveraged in multi-period economic analyses. The reduction process depends only on time invariant parameters and needs to be performed only once. The effectiveness of the method is shown on a large-scale real world power system.

12 - Assessing Models for Reducing Rate of Pavement Deterioration in Crack Sealing Treatments

Bortiorkor Nii Tsui Alabi, Purdue University, West Lafayette, IN, United States, Julius Keller, Samuel Labi

Cracks in highway/airfield pavements pose safety challenges as they lead to surface defects that impair utility and hence the need to apply treatments that reduce rate of deterioration by cracking. This study presents a model for determining effectiveness of crack sealing in terms of reduction in the rate of pavement deterioration. The model utilizes a functional form to account for pre-sealing level of deterioration and effort (maintenance dollars) expended on crack sealing treatments, thus facilitating an intuitive interpretation of the model formulation. Study result show sealing effectiveness does not exceed certain limit/cap. This cap is a function of the pre-sealing pavement condition.

13 - Adaptive Scheduler for Job-shop Problems: Reinforcement Learning on Disjunctive Graphs

Junyoung Park, KAIST, Daejeon, Korea, Republic of, junyoungpark@kaist.ac.kr, Jaehyeong Chun, Jinkyoo Park, Sanghoon Kim, Youngkook Kim

Job shop scheduling problem (JSSP) is an NP-hard problem with various applications in manufacturing domains. Due to the time-varying structure of a problem and the size of real manufacturing facilities, optimization methods are not applicable in practice. The majority of manufacturing facilities utilize rule-based dispatching methods to schedule production. Designing dispatching rules are dependent on experts' insight, which considers only partial information. We suggest a JSSP solver which is (1) adaptive so that it can schedule based on the real-time status of facilities with the understanding of the system (2) transferable so as to schedule any JSSP without additional training.

14 - Idle Vehicle Rebalancing in Manufacturing System Using Graph Neural Network and Multi Agent Reinforcement Learning

Kyuree Ahn, KAIST, Daejeon, Korea, Republic of, Jinkyoo Park

In this study, we propose a cooperative rebalancing strategy of idle vehicles to increase the productivity of the semiconductor system. We discretize the fab into zones and derive decentralized rebalancing strategies by applying a graph neural network (GNN) based multi-agent reinforcement learning (MARL). We first represent the fab into a directed graph to construct embedding values for each zone. After applying GNN to input graph, the node embedding values are then used to determine the cooperative rebalancing action from each zone in a decentralized manner. Simulation studies show that the proposed algorithm increases system-level performance compared to other strategies.

15 - Deep Learning-based Optimization of Battery Systems

Yifan Lu, UBC, Vancouver, BC, Canada, yifanlu823@gmail.com

The need for frequency regulation increases as wind power introduces frequencies never seen before. Battery systems are used in frequency regulation due to their flexibility and low price. In order to reduce the time in solving the optimization problem in each time step, the artificial neural network is employed to make this process faster without sacrificing its accuracy.

16 - Forecasting Wind Turbine Generation with Machine Learning Regression Model

Fei Sun, Texas State University, San Marcos, TX, United States, f_s38@txstate.edu, Tongdan Jin

Wind power is a main alternative energy resource, which has been applied broadly worldwide as moving towards an increasingly diverse energy mix to attain the emissions target in 2050. However, the challenge of utilizing wind energy is that the output of the wind turbine (WT) is intermittent and uncertain. Therefore, a hybrid wind speed forecasting method for estimating the short-term and long-term wind speed using advanced computer algorithms. Feedforward Artificial Neural Network (FANN) model and Recurrent Artificial Neural Network (RNN) models are applied. The primary result shows the machine learning models outperform the ARIMA model especially when the forecasting steps extend.

17 - A Hybrid AI Solution for Enterprise Client Advocacy Enhancement

Lei Huang, Research Staff Member, IBM Almaden Research, San Jose, CA, United States, Rodrigo Goulart Silva, Belen Gutierrez Gomez, Marie Hamburg, Elizabeth Regina Carreiro, Kim Christopher Cabugos, Jay Arvin Lego, Guangjie Ren, Vinicius Souza

How to improve client advocacy has been a great challenge for enterprise and large organizations given their large business size, versatile business services/products, and large number of touchpoints along the client journey. In this work, we propose a hybrid AI solution based on dictionary and machine learning methods for client surveys classification and insights extraction, thereby enhancing client advocacy. The solution has been implemented and applied to IBM client surveys that are collected through Medallia platform. We not only share results and improvements, but also discuss the future directions.

18 - Design and Maintenance for the Data Storage System Considering System Rebuilding

Jun Wang, University of Chinese Academy of Sciences, Beijing, China, wangjun172@mails.ucas.ac.cn
Jun Wang, Rutgers University, Piscataway, NJ, United States, wangjun172@mails.ucas.ac.cn, Xiaoyan Zhu, Tao Yuan

Considering the working and failure modes and maintenance process of a data storage system, we propose and study a reliability and maintenance model of a k-out-of-n:F system, in which the system experiences a rebuilding process with downgraded performance that follows preventive maintenance (PM) with replacement of failed components, and the system is subject to failure with different failure criteria during such rebuilding process. the external shocks would occur and possibly result in the failure of all the components. These characteristics bring in a new reliability and maintenance model and a new optimization problem that synthetically determine system reliability design and PM schedule.

19 - Sustainable Operations of Vertical Farm with Onsite Renewables Integration

Jose Luis Ruiz Duarte, University of Arizona, Tucson, AZ, United States, jlruizduarte@email.arizona.edu, Neng Fan

Controlled environment agriculture improves food systems efficiency by simulating ideal environment for crops growing, with the drawback of highly energy intensive operations. We present a mathematical programming model for optimal lighting system scheduling of vertical greenhouses with onsite energy storage systems and renewable energy sources operating under demand-side management policies.

■ Poster Session

CC- Exhibit Hall, Level 4

Monday Poster Session

Poster Session

1 - Strategic Inference under Private Sampling

Erik Miehling, University of Illinois at Urbana-Champaign, Champaign, IL, United States, Roy Dong, Cedric Langbort, Tamer Basar

We present a simple model to analyze the strategic signaling effects present when an agent’s learning process is partially observed by another agent. By computing the perfect Bayesian equilibria of the game, we characterize when a rational agent should collect private information and how the information influences future play.

2 - Application of a Flexible Gradient Descent to Machine Learning

Mostafa Rezapour, Washington State University, Pullman, WA, United States, mostafa.rezapour@wsu.edu, Nairanjana Dasgupta

One of the most widely optimization methods in machine learning is Gradient Descent. It is an iterative method that estimates model parameters by minimizing the error function. It reduces the error by stepping a specific length (learning rate) toward the steepest descent direction (negative gradient). The learning rate is a hyper parameter, which means it is fixed. However, in this poster we show that by converting the learning rate from a hyper parameter (fixed value) to an adjustable parameter, we can guarantee that the algorithm obtains the model accuracy faster and independent of the initial choice of the learning rate.

3 - Behavioral Business Intelligence Approach for Occupational Health & Safety

Abdulaziz Ahmad, Assistant Professor, University of Minnesota-Crookston, Crookston, MN, United States, aaahmed@crk.umn.edu, Salih Tutun, Sedat Irgil, Ilker Yesilkaya, Tulay Korkusuz

This research aims to develop a Behavioral Business Intelligence (BBI) approach for investigating problems to improve Occupational Health and Safety (OHS). We collected the dataset with 270 workers and 630 features. We utilized and proposed the Heterogonous Similarity Function to capture relations of workers by looking at behaviors and the Company’s structure. Afterward, based on relations, a network model is developed to analyze workers’ personality, and it explains the relationship between psychological status of the workers. Finally, we defined around 30 outliers (workers) that have problems for OHS, and we defined alpha/alphas leaders of the group for managing the OHS system.

4 - Effect of EHR Use and Information Security Controls on Time-sensitive Emergency Care Process Quality at U.S. Hospitals

Eric Johnson, Dean and Professor of Strategy, Vanderbilt University, Nashville, TN, United States, Ajit Appari

In this study, we examined the impact of EHR use on the emergency care performance; and how the cybersecurity controls adopted by hospitals affect this relationship between EHR use and emergency care performance. We analyzed 2,746 non-federal US hospitals based on data from multiple sources for year 2015 using generalized linear model for three process outcomes: median time to ECG for chest pain/heart attack, median time in ED for hospitalized patients, proportion of cases that had CT/MRI results available within 45minutes of arrival. We find mixed evidence on the ‘impact’ of EHR use and cybersecurity controls on emergency care performance.

5 - Association of Information Technology Use and Provider Characteristics with Opioid Prescribing Rates in the United States

Ajit Appari, Vanderbilt University, Nashville, MA, United States, aappari.work@gmail.com

The rising growth of electronic health record (EHR) systems among providers may help to stem the Opioid crisis as they could make informed decisions. In this cross-sectional study, I examined the association of provider-level Opioid prescribing rates with their EHR use, select provider characteristics and market competition by estimating mixed-effects generalized linear model regression, adjusting for patient population characteristics. Analysis of 892,664 providers (data obtained from 2016 Medicare Part-D prescription program file) suggests that EHR users and providers at larger practices and facing high competition are less likely to prescribe Opioids.

6 - ExpenDrogram – Comprehensive Visualization of Segmentation Over Time

Anna Khalemsky, Bar-Ilan University, Ramat Gan, Israel, anna.khalemsky@gmail.com, Roy Gelbard

In a big and dynamic data environments, the visualization of a segmentation process over time often doesn’t allow the user to monitor different aspects simultaneously, thus the main goal of ExpenDrogram visualization technique is to improve the comprehensiveness of a visualization analysis in order to support the decision-making process.

7 - What Information Support Does a Regional Innovation System (RIS) Need? Comparing Government-driven RISs with Grassroots-driven RISs

Benjamin Matheson, University of New Mexico, Albuquerque, NM, United States, Urusha Thapa, Fred Phillips

A regional innovation system (RIS) supports the diffusion of knowledge across economic, social, political and institutional relationships. With the support of information infrastructures, a successful RIS promotes the translation of knowledge into new technologies and products. This research focuses on current information infrastructures found in various RISs. The research team compared a government-driven RIS (Daejeon, Korea) with grassroots-driven RIS (Austin, Texas and Oregon, USA). The empirical bases are taken from in-depth interviews with regional initiative leaders, statistical data, historical documents, and research literature.

8 - Classification Methods with Neural Networks and Hybrid SVM

Enrique Martinez, Student, Heritage University, Yakima, WA, United States, John Tsiligaridis

Support Vector Machine (SVM) is an accurate classification method but computationally infeasible on large datasets due to time and space complexities. To reduce training complexity of SVM a hybrid SVM (DT_SVM), based on a probabilistic Decision Tree and Tabu Search algorithms, is developed. Superiority of SVM over Neural Network and simulation results with different complexity data sets are provided.

9 - Machine Learning for Objective Pain Measurement

Fatemeh Pouromran, Graduate Research Assistant, Northeastern University, Boston, MA, United States, pouromran.f@northeastern.edu, Sagar Kamarthi

Objective pain measurement has long been clinician’s Holy Grail for effective pain management. In practice, they typically rely on the patient’s self-report which doesn’t work when patients are not alert and cooperative. In this study, we developed the objective pain measurement model based on physiological signals and machine learning techniques.

10 - Impacts of Multimodal Information in E-commerce: An Analysis of Verbal, Visual and Affective Information in Videos on Sales

Gaurav Jetley, University of South Florida, Tampa, FL, United States, gauravjetley@mail.usf.edu, Shivendu Shivendu

Unlike textual reviews, videos convey information on multiple dimensions, yet, there is little research on their impacts on sales. Previous literature also have contrasting findings on persuasiveness of rich presentation and visual cues. We investigate the impacts of verbal, visual and affectual information in customer, professional and manufacturer videos on product sales. Among other results, we find video aspects such as word speed, length & scenes have inverse U-shaped relationship with sales, clarifying contrasting results from previous studies. We discuss implications to practice and theory.

11 - Amplifying the Imitation Effect for Reinforcement Learning of UCAV’s Mission Execution

GyeongTaek Lee, Yonsei University, Seoul, Korea, Republic of, SangJin Kim, ChangOuk Kim

This paper proposes a new reinforcement learning algorithm that enhances exploration by amplifying the imitation effect (AIE). This algorithm consists of self-imitation learning and random network distillation. We argue that these two algorithms complement each other and that combining these two algorithms can amplify the imitation effect for exploration. In addition, by adding an intrinsic penalty reward to the state that the RL agent frequently visits, the AIE leads to deep exploration. We applied the AIE to a simulated environment of unmanned combat aerial vehicle (UCAV) mission execution, and the empirical results show that AIE is very effective for finding the UCAV’s shortest flight path.

12 - Adaptive Neural Architecture Optimization for Medical Image Analysis

Haifeng Wang, Assistant Professor, Mississippi State University, Mississippi State, MS, United States, wang@ise.msstate.edu

Optical Coherence Tomography (OCT) is an interferometric imaging modality that can visualize biological microstructure via cross-sectional images. Machine learning algorithms have been widely applied and investigated for automatic medical image analysis. However, neural architecture is a crucial aspect that influences the performance of convolutional neural networks (CNNs). Identifying an effective CNN architecture requires a great amount of time and efforts due to the complexity of CNN connections. To overcome the challenge, an adaptive neural architecture optimization (ANAO) model is proposed, which can adaptively design and optimize the CNN structure based on a given dataset. Neural blocks are designed as basic elements in the optimization process. Experiment results are conducted on retinal disease diagnosis and show that the proposed models can obtain higher accuracy for both 2D and 3D OCT image classification tasks.

13 - The Role of Social Network Sites on the Relationship Between User and Developer in Games: An Evolutionary Game Analysis for Virtual Goods

Haitao Chen, Jilin University, Changchun City, China, htchen@126.com, Chen Hao, Dong Zhaohui

Recently, the emergence of social network sites (SNS) has gradually solved the dilemma of online games that neither of game developer and user takes little consideration on virtual goods. This paper adopts the evolutionary game method to model the repeating multi-stakeholders progress and finds that it is the social influence of SNS drives both sides to take positive strategies on virtual goods market through the impact of other players in games.

14 - Real-time Significant Wave Height Classification from Raw Ocean Images Based on Convolutional Neural Network

Heejeong Choi, Korea University, Seoul, Korea, Republic of, heejeong_choi@korea.ac.kr, Pilsung Kang

Among various ocean conditions, a wave height is one of the most significant considering factors for economic routing which aims at reducing fuel expenses. The previous approaches have estimated the ocean-wave conditions by either solving equations or training machine learning models. The former cannot estimate the wave heights in real time and the latter did not fully utilize the wave images. In this paper, we propose a real-time convolutional neural network (CNN)-based significant wave height level classification model based solely on raw ocean images. To achieve higher classification accuracy efficiently, four CNN structures are and two image preprocessing techniques are investigated.

15 - A Deep Reinforcement Learning Approach for the Stochastic Inventory Problem

Henri Dehaybe, UC Louvain, Gembloux, Belgium, henri.dehaybe@uclouvain.be

We consider the classic Single-Level Stochastic Inventory Problem (SL-SIP) and we propose a heuristic to identify close to optimum policies based on Deep Reinforcement Learning. The neural network at the core of the heuristic can be extended to a continuous demand space and proves able to approximate the optimal (S,s) policy after an appropriate training on random instances of the problem. The proposed approach to solution of the problem is novel in the literature of the SL-SIP and constitutes a further example of the benefit that a cooperation between optimization and machine learning can bring both to the respective research areas and to practical problem solving.

16 - Big Data Research in Information Systems: A Meta-analysis

Hua Dai, Associate Professor, California State University-Channel Islands, Camarillo, CA, United States, hua.dai@csuci.edu, Tao Hu, Xi Zhao

Based on an extensive literature review and meta-analysis of 176 articles published in the “Senior Scholars” list of the eight information systems (IS) focused academic journals over the period of 2000-2019, this study reports the preliminary findings of topics and methodologies of Big Data research in the IS field. The meta-analysis compares research methodologies applied and topic areas investigated, and identifies the emerging research trends. Then, a research framework of Big Data is proposed to synthesize and aid in theoretical perspectives and empirical studies of the Big Data research in the IS field.

17 - Health Monitoring and Anomaly Detection of a Power Plant Boiler Using Unsupervised Autoencoder

HyoJung Kim, Undergraduate Student, Chosun University, Gwangju, Korea, Republic of, Seongjoon Kim, Seongjoon Kim

Please check the mobile app for this abstract.

18 - A Conditional System Health Index Based Prognostics and Health Management Method for Uncertainty Management

Jaeyeon Jang, Yonsei University, Seoul, Korea, Republic of, jjy009@yonsei.ac.kr, Daeyeol Yang, Chang Ouk Kim

This study proposes using a deep conditional health index extraction network (DCHIEN) for prognostics and health management (PHM) to effectively manage uncertainty. DCHIEN is a model that combines a stacked denoising autoencoder with a neural network that extracts a health index (HI) based on user-defined monitoring conditions. This approach supports system health monitoring using the conditional HI, as well as prognostics. We conducted experiments using NASA's turbofan engine degradation data. The results showed that the proposed method showed a superior remaining useful life prediction performance compared to existing methods and that uncertainties can be effectively managed.

19 - Handling Nonignorable Missing Values in Information Systems Research: Toward Imputation with Machine Learning

Jiaxu Peng, National University of Singapore, Singapore, Singapore, j.peng@u.nus.edu, Jungpil Hahn

We review top IS journals and show the ubiquitous existence of missing values in quantitative empirical research. To handle missing values, modern approaches often assume missing at random (MAR) although in many cases we often strongly suspect missing not at random (NMAR). We propose a missing value imputation method which considers the missingness mechanism and increases the robustness to the NMAR mechanism. Moreover, our method can be extended to imputation using machine learning algorithms which enable potentially more accurate imputation. This study has important implication for both quantitative empirical researchers, not only for IS researchers, as well as practical data analytics.

20 - Time Series Models in the Presence of Ouliers or Extreme Values

Mian Arif Adnan, Graduate Student, Indiana University Bloomington, Bowling Green State University, Bowling Green, OH, United States, maadnan@iu.edu

Estimates of the Time Series Models suffer from the exaggeration of the contribution of the outlier(s) or extreme observations. Time Series Models based on least deviation method have been developed to minimize the total sum of errors. It also suggests some new measures of fit.

21 - Explainable Machine Learning Model for Crop Yield Prediction

Javad Ansarifar, Iowa State University, Ames, IA, United States, ansarifar.javad@gmail.com, Lizhi Wang

Crop yield prediction is important because accurate predictions help farmers to make right decisions, allow seed industries to evaluate new varieties, and support famine-prevention efforts. The existing methods are either accurate models like machine learning models or explainable models like crop models. We designed a new explanatory predictive framework, which integrates domain knowledge of crop science into the explainable predictive framework. Optimization tool was used to determine the best combinations of explanatory variables leading to high crop yield. Comparison of the new model with existing models reveals that using the proposed model improves crop yield prediction.

22 - Optimization of Retrieval Rate Based on Minimal Information

Babu K. Baniya, Assistant Professor, Grambling State University, Ruston, LA, United States, baniyab@gram.edu

We proposed the minimal information approach that calculates the different statistics to preserve the distinctive information from extracted features. The bunch of audio features was extracted and calculated low- (mean and variance) and high order statistics (skewness and kurtosis) from them. In the next stage, linear discriminant analysis (LDA) algorithm was implemented to acquire the distinctive knowledge from the feature pool and the outcome presented in the 2-dimensional space. The distinctive features divided into ten-fold and fed into the kernel support vector machine (SVM) to determine the corresponding class label. The overall accuracy is 84.75%.

23 - A Dynamic Transit Model for Vulnerable Road Users

Justice Darko, Student, North Carolina A&T State University, Greensboro, NC, United States, jdarko@aggies.ncat.edu

Vulnerable road users (VRUs) are most sensitive to risk and uncertainties in transit networks. In many scenarios, these travelers prefer decisions that is one-shot, avoiding high-risk actions. We model the behavior of the constant risk-sensitivity of these travelers by assuming the exponential function. Integrating the exponential function into Markov Decision Process ensured that the actions taken by the traveler is now conditioned on the level of uncertainty and risk in the stage of decision making. In general, integrating the exponential utility presented a personalized transit model for VRUs enabling them to take actions that lead to less regret.

24 - Marketing Analytics in Banking

Mou Dutta, Genpact, New York, NY, United States, drimjhim36@gmail.com

Customer churn is one of the most notable business challenge for any marketer.

25 - Developing Ensemble Predictive Model for Supplier Assessment

Ramkumar Harikrishnakumar, Supply chain research analyst, Wichita state university, Wichita, KS, United States, hramkumar21@gmail.com, Vatsal Maru, Alok Dand, Krishna Krishnan, Saideep Nannapaneni

Supplier assessment is a multi-criteria decision making approach that requires several criteria for the proper assessment of the suppliers. For a comprehensive and robust assessment process, we propose machine-learning algorithms to classify various suppliers into four categories: excellent, good, satisfactory, and unsatisfactory. In this paper, machine learning algorithms (especially classification algorithms) are applied for a supplier assessment problem. Machine learning techniques that include bagging and boosting methods are used to create various ensemble classifiers from training data, and their performance is measured using test data.

26 - Machine Traders Beat Man Traders? Why?

Bo Han, Texas A&M University-Commerce, Commerce, TX, United States

Algorithmic trading (AT) has gained tremendous popularity. This paper compares the decision making features between AT based trading and human controlled trading, and propose useful framework to fund managers.

27 - Effectiveness of Decision Making Strategies in Uncertain and Time-Sensitive Environments

Mark Calafut, George Washington University, Washington, DC, United States, mcalafut@gwu.edu, Shahram Sarkani, Thomas Mazzuchi

Decision making strategies are often applied in challenging environments, characterized by uncertainty and time-sensitivity. This situation was modeled as a stochastic knapsack optimization that considered multiple criteria for arriving opportunities. Online and periodic strategies were implemented in simulation and their performance was characterized at levels of opportunity variety, uncertainty, and time-sensitivity. At low and moderate uncertainty, online strategies created more value and at high uncertainty, periodic strategies created more value. In cases where uncertainty and time-sensitivity are not well known, online methods are preferred due to greater robustness.

28 - A Data-based Competitive Market Strategy Model for Higher Education Organizations

Scott J. Warren, Professor, University of North Texas, Denton, TX, United States, scott.warren@Unt.edu

Like their for-profit brethren, universities seek to determine whether there is demand for their academic products before going to the expense of marketing them to prospective students. However, until recently public universities were supported by substantial state funds, meaning this was not a concern. Many higher education organizations have small marketing departments primarily focused on protecting branding, rather than on using the marketing concept to analyze potential markets to determine demand for their academic products as part of a broader recruitment strategy. This piece explores how some U.S. universities can exploit market-based analytic approaches to better compete.

29 - Integrated Deep Multi-task Learning and Stochastic Optimization Approach for Chronic Disease Operations Management

Mohammad Hessam Olya, Wayne State University, Detroit, MI, United States

Efficient managing of chronic disease operations leads to a reduced healthcare operation cost. In this study we propose an integrated approach for chronic disease operations management. We developed a deep multi-task learning approach for patient workload prediction. Then, we suggested a stochastic optimization model for capacity planning in the healthcare system. This approach leads to chronic disease operations cost reduction by using data analytics and operations research techniques in order to plan for required resources and allocate them to the patients based on their various demand while balancing workload of the resources.

30 - Decision Making Using Multi-task Learning

Mohammad Hessam Olya, Altair Product Design, Troy, MI, United States

Using single-task learning approaches as prediction methods to assist decision makers became common, lately. Depending of the problem type, different single-task learning approaches are sufficient for getting fair and reasonable outcomes. But for certain problems, we need to use multi-task learning approaches in order to increase the efficiency of algorithm. In this research we explain some applications of multi-task learning as well as its advantages for decision makers.

31 - A Decision Support Tool for Defense Planning

Sandra Huber, Defense Planning, München, Germany, hubersandra100@gmail.com

One of the key challenges for defense planning is to define capabilities to meet the mission requirements. In addition, promising projects have to be selected to fulfill the expected outcome. The selection of projects includes several factors, such as multinational commitments, political-military strategy of the German Federal Ministry of Defense as well as the capability guidelines of the German Armed Forces. We developed a multi-stage genetic algorithm solution approach for the resource-constrained project scheduling problem and investigated different versions of the algorithm on several instances.

32 - Comparative Analysis of User Innovation Mechanisms: A Mechanism Design Approach

Sangjic Lee, Doctoral program student, The University of Tokyo, Tokyo, Japan, sangjiclee@css.t.u-tokyo.ac.jp, Kohei Nishiyama, Nariaki Nishino

This study aims to compare the various pathways of user innovation commercialization with the mechanism design framework. By conducting a case study of the Lego company and examining it along with the existing literature, a set of shared game model elements is constructed. Then five mechanisms - user entrepreneurship, user community, personalization, crowdsourcing, and in-house innovation as a benchmark case - that contain different message sets and outcome functions are formulated with the elements. With other features being controlled, the pure-strategy equilibria are searched and the implementability of the social choice function is compared under several preference settings.

33 - Evaluating Stakeholder-driven Criteria for Airfield Pavement Investment

Bortiorkor Nii Tsui Alabi, Purdue University, West Lafayette, IN, United States, Tariq U. Saeed, Julius Keller, Samuel Labi

A comprehensive and explicit definition of performance goals and associated decision criteria is critical for ex ante or ex poste evaluation of investments. In application of airport runway pavements, this can help airport authorities to assess consequences of alternative investment actions as costs and benefits accruing to the airport authority, users, and society. This study synthesizes concepts of stakeholder-related criteria for evaluating airport runway pavement investments and provide airport authorities with guidelines (including criteria dimensions and desired attributes) to identify appropriate decision criteria for investments.

34 - Feature Based Procurement Contract for Intermediary Agri-service Providers with Co-production

Omkar D. Palsule-Desai, Indian Institute of Management-Indore, Indore, India, omkardpd@iimidr.ac.in, Yini Gao, Teo Chung Piaw

A challenge for an intermediary agri-service provider is achieving an appropriate balance between yield improving efforts and assured prices to be offered to the farmers. We develop a noncooperative game theoretic model that captures farming yield of traditional and high-value farm-produce, the trader's commission rates in the open-market, and the supply chain players' farming and effort-cost functions. We describe the economics associated with co-production, gather farmer level data from a firm, and validate observed behavior of players in the real-world setting.

35 - A Case Study in Line Balancing and Simulation

Chelsea Spence, Clemson University, Clemson, SC, United States, cspenc2@g.clemson.edu, Alexis Fiore, Adarsh Jeyes, Edwin Chase Wentzky, Ibrahim Ozan Yilmazlar, Nicole Zero, Mary Beth Kurz, Joshua D. Summers, Kevin M. Taaffe

Assembly line balancing allocates individual tasks to work stations while respecting physical, safety, and quality constraints. Because this is an NP hard problem, it is often difficult to find an optimal solution. We balance a two-sided transfer line using integer programming, metaheurisitics, and simulation and compare the methods. The methods are evaluated based on data from a currently operating assembly line for a local OEM.

36 - Tele-medicine Value for Patients, Payers, Providers, and Society

David D. Cho, Woodbury University, Burbank, CA, United States, Jon M. Stauffer

Medicare and many insurance providers do not reimburse providers for constant patient tele-monitoring. However, with today's pay-for-performance reimbursement plans, there can be benefits for discharged patients, such as shorter skilled nursing facility stays and reduced readmissions with follow-up monitoring immediately after discharge. We model the costs and benefits of tele-monitoring in a multi-period setting to study the cost-effectiveness and design of reimbursement plans for different players involved.

37 - Pricing Strategies of Dual—Channel Closed—Loop Supply Chain under Government Reward—Penalty Mechanism

Haitao Chen, Jilin University, Changchun City, China, htchen@126.com, Dong Zhaohui, Chen Hao

Government plays an important role in the products recycling in order to encourage sustainability. This research develops two dual channel closed-loop supply chain models with the government reward-penalty mechanism under different collecting scenarios. And we explore which collecting model is more efficient. Our equilibrium results show that the direct collecting model is prior to the third-party collecting model. In addition, the sensitive analysis indicates that the government financial intervention can moderate the channel conflict and competition. We further provide the government with the method to find the optimal to maximize the total social welfare with the approximate budget.

38 - Retail Competition at the E-commerce Era

Qiang Li, Rutgers University, Newark, NJ, United States, Xiaowei Xu

We study retail markets, in which brick-and-mortar retailer competes against an e-retailer. Many department stores announced to close more stores. On the other side of the competition, e-retailers have been growing their business at a double-digit annual rate. The brick-and-mortar retailer needs scale constraint. We build a mathematical model and try to answer some questions such that: will online retailers win the final trophy and eliminate more local stores in the next decade? What's the suitable population density that a local store should cover?

39 - Inventory and Pricing Decision for a Non-instantaneous Deteriorating Item under Environmental Investment

Sepideh Zohoori, Doctorate of Engineering, Lamar University, Beaumont, TX, United States, szohoori@lamar.edu, Reza Maihami, Iman Ghalehkhondabi

Fresh fruit, vegetable, and frozen fast food are known as "non-instantaneous deteriorating items". These items keep their original quality for a span of time, then the normal deterioration process begins. In this paper, a new inventory control model for a non-instantaneous deteriorating item is presented. The demand depends on selling price and level of environmental improvement. This paper aims to indicate the optimal price, inventory control variables, and level of environmental improvement simultaneously such that the vendor's total profit is maximized. the proposed model is designed according to a non-linear optimization model and the analytical closed-form of the solution is computed.

40 - Cooperative Advertising in a Dual-supply Chain under Asymmetric Market Information

Yan Zong, Renmin University of China, Beijing, China, zongyanrbs@ruc.edu.cn, Jianghua Wu

This paper focuses on the incentive for vertical information sharing in the context of cooperative advertising within a dual-channel supply chain. Our results show that information sharing leads to an increase in supplier's profit and, under certain conditions, in the whole supply chain's. The retailer can also be better off when supplier "reverse" the retailer's purchase to support advertising.

41 - Multi-image Monitoring with MPCA for Statistical Process Control

Shengfeng Chen, Western Michigan University, Kalamazoo, MI, United States

A Two-image monitoring framework is introduced and proved to be more sensitive to a wide range of shifts than a single-image framework. Specifically, two images being monitored are fused together with Multilinear Principal Component Analysis (MPCA) and then monitored through a Multivariate Exponential Weighted Moving Average (MEWMA) control chart. The proposed image-fusion MEWMA outperforms either 2-MEWMA combinations or individual MEWMA in detecting wide range of shifts. The spatial cross-correlation between images is investigated and indicating images with weaker cross-correlation can increase control chart's sensitivity to process shifts.

42 - Underpricing in SME Initial Public Offerings

Hariprasad Bellamkonda, IIM Indore, Indore, India, hariprasad@iimidr.ac.in

The signalling role of underwriters and auditors in underpricing of SME initial public offerings in the aftermath of demonetisation was examined in this study in Indian context. This study reveals that the underwriter's presence has reduced the information asymmetry thereby signalling the issue quality to investors. The interaction effect between the underwriter and the auditor examined in this context reveals that underwriter reputation plays a significant role in decision making.

43 - Toward Green Fashion Design: A Systems Engineer's Perspective

Ana G. Duque, Rensselaer Polytechnic Institute, Troy, NY, United States, duquea@rpi.edu, Jennifer A. Pazour, Sérgio Pequito

The objective of this research is to determine if industrial hemp fiber can be produced as a competitive alternative to cotton. Through the elaboration of a holistic supply chain, the fiber production process of both textiles is juxtaposed, highlighting key economic and environmental considerations. All stages of fiber production are measured under three main pillars: time, cost and yield. Preliminary results show industrial hemp as a high yield crop with at least 8 times more tonnes of fiber per hectare cultivated and lower ecological footprint than cotton. The continuing research aims to demonstrate that industrial hemp fiber has the potential to become a staple within the fashion industry.

44 - Differentiating Interhospital Transfer Types: Varied Impacts and Diverging Destination Choice Strategies

Raymond Lei Fan, University of Houston, Houston, TX, United States, raymondfan@bauer.uh.edu, Ming Zhao, David Xiaosong Peng

This study first develops a method to empirically separate clinical interhospital transfers (IHTs) from non-clinical IHTs. Next, we evaluate their impacts on care outcomes and find: (1) clinical IHTs are associated with better outcomes than non-clinical IHTs; (2) for non-clinical IHTs, transfers within the same healthcare system are associated with better outcomes than those out of the system, whereas for clinical IHTs, destinations out of the system are better than those in the system. We use Heckman selection model and propensity score matching to address potential sample selection bias. The results provide managerial insights on IHT destination choice strategies.

45 - Equilibrium Analysis in Dual-channel Supply Chain with Dominant E-tailers

Jin Zhang, RWTH Aachen University, Aachen, Germany, zjchitu@gmail.com

This paper models the strategic interaction between e-tailers and a monopolistic manufacturer and allows that e-tailers have price-setting power vis-à-vis the manufacturer. It investigates the performance of the manufacturer and the e-tailers in a model that incorporates a vertical variable and a horizontal variable and allows for a dominant e- tailer structure and a dominant manufacturer structure. It considers a two-stage game theoretical model that captures the two key factors and solves for an equilibrium. It compares the firms' performances under the two different power structures and investigates the magnitude of the e-tailers benefit that is related to a change in their bargaining power.

46 - Determine Slack in the Enterprise Operations Support

Pawan Chowdhary, IBM Research, San Jose, CA, United States, chowdhar@us.ibm.com, Sunhwan Lee, Guangjie Ren

Enterprise operations and Support (EO&S) provides back office service to the frontline sales force for IBM. It has thousands of staff that support several million service requests each year. We plan to present our analysis on capacity and utilization to identify the slack in the system for optimal performance

47 - Dynamic Pricing by Combining Xgboost and Dual Annealing

Abhinav Khare, University at Buffalo, Buffallo, NY, United States, abhinavk@buffalo.edu, Suirong Dong, Diala Gammoh, Sivalenka Amruth

Dynamic Pricing to maximise revenue requires an accurate estimation of the demand curve that varies with season, day of the week and other business-related factors. We developed a two-stage model to find the optimal price points for an online digital product where prices vary on daily basis. We used a machine learning model to capture the relationship between demand & all other factors in the first stage while we applied a simulated annealing algorithm to find the optimal price point in the second stage. We found out that xgboost algorithm outperforms other machine learning algorithms in predicting the demand on a large scale. The proposed methodology is estimated to increase the revenue by 20%.

48 - If You Want to Finish Your Next Project on Time, Work in Sprints! How Agile Project Management Improves Output Performance

Tobias Lieberum, Technical University of Munich, Munich, Germany, tobias.lieberum@tum.de, Sebastian Schiffels, Rainer Kolisch

At the heart of the agile project management approach Scrum is project execution through sprints. Sprints are short-term project phases characterized by timeboxed progression to the next sprint and self-contained output goals for every sprint. We experimentally show for a given duration that in the absence of timeboxed progression and phase-specific output goals participants spend too much time on early at the expense of late project phases. Timeboxed progression alone mitigates this effect, but does not improve the exerted effort. Phase-specific output goals alone lead to an amplification of the progression delay. The combination of both components results in a significant performance uplift.

49 - Personality Type and Systems Thinking Skills of Practitioners

Morteza Nagahi, Graduate Research Assistant, Mississippi State University, Starkville, MS, United States, mn852@msstate.edu

As organizations operate in more and more turbulent and complex environments, it has become increasingly important to assess practitioners' Systems skills Preferences (SSP) and Personality Types (PT). The current literature lacks studies related to the impact of practitioners' PT on their SSP, and this study aims to address this gap. A total of 99 engineering managers and 104 systems engineers provided the data to test four hypotheses posed in this study. The results show that the PT of practitioners have a positive impact on their level of SSP and that the education level, the current occupation type, and the managerial experience of the practitioners moderate the main relationship in the study.

50 - Navigating the Aisles: Nutritive Optimization for Single-parent Households

Jessica Knobloch, Saint Joseph's University, Philadelphia, PA, United States

The Nutritive Optimization Model (NOM) was designed to enable financially restricted households to leverage data-sharing technology for increased efficiency in planning grocery shopping trips. Twenty-one price points of commonly consumed perishable foods were collected from the ten largest grocery retailers in the United States to observe pricing variation across the country. Prices are displayed based on companies' national geographic presence. Pricing surveys were conducted to begin expanding NOM into a multi-objective linear program for nutritive optimization.

51 - Hostile Takeovers or Friendly Mergers?: A Real Options Analysis

Katsumasa Nishide, PhD, Hitotsubashi University, Kunitachi, Japan, Takeshi Ebina, Yuya Kumakura

This paper analyses a real options model of mergers and takeovers between two firms experiencing different, but correlated uncertainty in profits. It is assumed that firms can choose two alternatives; hostile takeover or friendly merger. In a hostile takeover, a bidder firm takes all the extra value but should incur merger costs, while in a friendly merger both firms do not bear merger costs and share the extra value through Nash bargaining. We shall show with numerical analysis the condition for which firm to be a bidder and for which form of amalgamation to happen.

52 - An Application of Hotspot Analysis for Optimal Location Analysis

Lakshika Nishadhi Kuruppuarachchi, The University of Toledo, Toledo, OH, United States, lakshika.nsh@gmail.com, Zonghua Xu, Matthew Franchetti

Food waste is the largest component of waste by weight in U.S.A. Food waste sent to landfill releases Green House Gas (methane) which is at least 28 times more potent than carbon dioxide. Residential food waste collection in the U.S.A has grown significantly in the past few years. The feasibility of introducing a commercial food waste collection program is studied. Currently, the study area does not have any food waste collection program and the food waste collection points needed to be identified. The study proposes the optimal places to be selected as the collection points using the hotspot analysis and then assign each demand point to the selected collection points.

53 - Causal Models to Identify the Most Responsive Customers to Email Promotions

Michael Bostwick, Squarespace, New York, NY, United States, mbostwick@squarespace.com

Modeling heterogeneous treatment effects can be used to identify customers most responsive to marketing efforts. We demonstrate the effectiveness of this approach at Squarespace to develop an optimal email promotion policy. We also show what the most responsive customers look like in terms of product and email engagement features.

54 - A Clothes Inventory Balancing Scheduling Problem in Fast Fashion Industry

Xiaodong Wang, Tongji University, Shanghai, China, xiaodongwang2017@tongji.edu.cn, Shijin Wang, Ruochen Wu, Li Yu

Fast fashion industry is a highly competitive business. Quick response capabilities are required to capture the fashionable trends and satisfy customers demands. Inspired by a real-world fast-fashion operation system, this study investigates a clothes inventory balancing problem, where a distributer schedules demanded clothes among a warehouse and several branch stores. A mixed integer programming is formulated with some practical constraints to maximize the distributor's total profits. A real-world illustrative case study is conducted to validate the effectiveness of the proposed model. Efficient heuristic and decomposition algorithms have been developing for further study.

55 - Environmental and Economic Modelling for Recycling Collection System in Lucas County

Zonghua Xu, University of Toledo, Toledo, OH, United States, Zonghua.Xu@rockets.utoledo.edu, lakshika Kuruppuarachchi, Matthew Franchetti

This study is to optimize the drop-off collection system for recyclables in Lucas County, to reduce the environmental and Economic cost, including reduction in total vehicle traveling miles and GHG gas emissions. There are two recycling streams: Fiber and commingled containers in Lucas County. The periodic vehicle routing Optimization models are built, which can fully applied to minimize the Environmental and Economic cost for the recycling streams in Lucas County. This study applied GAMS/CPLEX which based on branch and bound algorithm to solve the models. The analysis shows the validity of the models and algorithm. This work can be used in related theory of PVRP and reverse logistics.

56 - Determining Optimal Gasoline Fuel Delivery Strategies under Uncertainty

Dominiqueca Edwards, North Carolina A&T, Greensboro, NC, United States, dredward@aggies.ncat.edu, Lauren Berrings Davis, Pitu B. Mirchandani, Sierra Marshall

The uncertainty of how a hurricane can affect society is inevitable. In preparation for a hurricane, potential individuals affected by the hurricane often are required to evacuate. Evacuations can cause high increases in the demand for gasoline fuel needed for transportation. The fuel is imported by vessels which often have to divert from the intended destination port due to the path of a hurricane. The purpose of this research is to determine a real time port diversion strategy for incoming fuel vessels given the forecast of an approaching hurricane. We develop a heuristic scheduling algorithm that finds the optimal diversion strategy that minimizes the unmet demand of gasoline fuel in each county.

57 - Using Buffered Probability of Exceedance in Risk Management

Giorgi Pertaia, University of Florida, Gainesville, FL, United States, gpertaia@ufl.edu, Stan Uryasev, Artem Prokhorov

Credit ratings are fundamental in assessing the credit risk of a security or debtor. The failure of the CDO ratings during the financial crisis of 2007-2008 and the massive undervaluation of corporate risk leading up to the crisis have caused a review of the ways ratings are constructed. Yet the fundamental risk metric that guides the construction of credit ratings has not changed. We present a new methodology based on a buffered Probability of Exceedance (bPOE). The new approach offers a conservative risk assessment, with substantial conceptual and computational benefits, which we illustrate using synthetic and real-world financial data.

58 - A Multi-objective Optimization Model for Designing Industrial Symbiosis Network

Lufei Huang, Shanghai University, Shanghai, China, huanglufei@shu.edu.cn

Waste material produced by industrial manufacturing processes is one of the main sources of environmental pollution. The industrial symbiosis initiative, which aims to address the economy, the environment and society synchronously, is regarded as an effective sustainable solution. Waste material exchange, similar to water exchange and energy exchange, is one of the key links that to be put into practice at the beginning of industrial symbiosis. However, very few studies develop a tri-objective optimization model for material exchanges decisions in the industrial symbiosis networks. This study presented a multi-objective model regarding the material exchange decisions, which simultaneously accounts for the three pillars of sustainability. By-product flow, material reprocessing node and reprocessing technology level selections are formulated in a Mixed-Integer Programming model. An Epsilon-constraint approach is provided to tackle with the presented multi-objective model efficiently. Affected by the trade-off among three objectives, nine scenarios derived from objective priority are employed to review the performance of the proposed symbiosis network. Computational results verify that our approach is effective for obtaining solutions. Some managerial insights highlighted from numerical analysis are presented for industries' practice.

59 - Joint Pricing and Ordering Decisions to Manage Deteriorating Inventory

Omid Jadidi, Assistant Professor, St Edward's University, Austin, TX, United States, ojadidi@stedwards.edu

A perishable product of different ages are usually displayed side-by-side on shelves. Ageing items, in most situations, become less appealing to customers. This study considers a joint pricing and inventory management problem in which a retailer sells a perishable product of two different ages. The demand for the product is assumed to be price- and time-dependent. We formulate the problem by using a mathematical programming approach and develop an algorithm to solve it numerically. The numerical analysis shows that an appropriate pricing decision can reduce the waste considerably. Further results are discussed to bring some managerial insights.

60 - Approximation Ratio of LPT* Algorithm for Multi-Processor Scheduling

Peruvemba Sundaram Ravi, Associate Professor, Wilfrid Laurier University, Waterloo, ON, Canada, pravi@wlu.ca, Jackie W. Baek, Levent Tuncel

In 1993, Eck and Pinedo proposed a heuristic algorithm, the LPT* algorithm, to minimize makespan over flowtime-optimal schedules for a set of jobs on a set of parallel identical machines. Their algorithm was an extension of a very well-known list scheduling algorithm, Longest Processing Time (LPT) list scheduling, to this bicriteria scheduling problem.They proved that, for the two-machine case, their algorithm had a worst-case performance ratio of 28/27. Huang and Tuncel (2004) proposed worst-case performance ratios for the case when the number of machines exceeds two. We outline an approach that may lead to a proof of the ratios proposed by Huang and Tuncel.

61 - Using Twitter to Analyze Tesla Stock Price

Richard Gruetzemacher, Auburn University, Auburn, AL, 36830, United States, Sam LaPlatney, Brett Roeber

This study uses Twitter data to analyze sentiment of Tweets concerning Tesla and Tesla's stock price. We compare relevant hashtag sentiment and the sentiment from cashtags. There are significant differences between hashtag sentiment and cashtag sentiment, with hashtag sentiment sometimes being a better indicator of Tesla's stock price. This suggests that previous automated trading systems developed based on sentiment analysis of Twitter cashtags may be enhanced by also including sentiment information from hashtags.

62 - Evaluating Alternative Network Designs for Closed Loop Supply Chain Using SNA Metrics

Sara Akbar ghanadian, Ohio university, Athens, OH, United States, sa129715@ohio.edu

Social Network Analysis (SNA) has been developed to identify and analyze the patterns in social networks. Although SNAis a powerful method to study networks in many areas, it has not been comprehensively applied to supply chain networks. Likewise, there is no application and interpretation of SNA metrics in closed loop supply chains (CLSCs). In this study, SNA metrics are introduced and interpreted for components in CLSC networks and forward and reverse logistic activities. Correspondingly, a decision making tool is developed based on selected SNA metrics for comparing alternative network designs in terms of network reliability and balance of the flows.

63 - Overlap Packing Optimization for Spacecraft Layout Design

Richard Alaimo, University of North Carolina-Charlotte, Charlotte, NC, United States, ralaimo@uncc.edu, Claudia Ramirez-Wade, Churlzu Lim, Simon Hsiang, Maijinn Chen, John Arellano, Jerry Myers

This study considers the layout design of a spacecraft where adjacency and volume are optimized using a biobjective mixed-integer linear program. The model can generate design alternatives accommodating physical design requirements and the designer's preference. Noting the NP-hardness of the problem, enhancements are proposed and tested to improve computational efficacy.

64 - Optimization of Production and Packaging Schedules in a Mixed Discrete Continuous Manufacturing Environment

Faraz Dadgostari, Univ of Virginia, Charlottesville, VA, United States, fd4cd@virginia.edu, Jarett Cestaro, Peter A. Beling

Please check the mobile app for this abstract.

65 - Sonoco Uses a Stochastic Lot sizing and Scheduling Model to Optimize the Production of Coreboard

Niels De Smet, Ghent University, Ghent, Belgium, nedsmet.desmet@ugent.be, Solventure, Ghent, Belgium, Stefan Minner, El-Houssaine Aghezzaf, Bram Desmet

Since several years we have been working together with the European supply chain team of Sonoco, one of the largest global players active in the packaging industry, to solve a variety of supply chain challenges encountered in their industrial products & services division. In this work, we present the result from a pilot project related to production planning for which we developed a novel stochastic lotsizing and scheduling model and a solution approach tailored to their specific business environment.

66 - A Data-driven Analysis of Competitive Free Shipping Policies by Online Retailers

Gihan S. Edirisinghe, Washington State University, Pullman, WA, United States, gihan.edirisinghe@wsu.edu, Charles L. Munson, Narmada Balasooriya

Amazon Prime has revolutionized home delivery cost perceptions. We develop a model using non-linear MIP to analyze several common shipping programs used by online retailers to determine the best policies under different circumstances and make recommendations. We build a Python-based web crawler to obtain data from Amazon for this analysis. We find at current industry parameter levels that shipping policies with a membership free shipping component are more profitable. Our results indicate that the cost savings felt by customers significantly vary across different policies based on many factors. We also make recommendations on setting optimal membership fees and free shipping thresholds.

67 - Optimize the London Bike Sharing System through Advanced Analytics

Filippo Focacci, DecisionBrain, Paris, France, contact@decisionbrain.com

Based on machine learning and mathematical optimization models, DecisionBrain's applications are used every day to optimize the workforce of market leaders in the Services industry such as ISS, JLL and Serco. In this session, we will discuss how we optimize operations for the London Cycle Hire (LCHS), one of the largest bikes sharing systems in the world and their mobile workforce.

68 - Preferred Boarding Passes Optimization by Markov Chains

Jose G. Flores-Muniz, Tecnologico de Monterrey, Monterrey, Nuevo Leon, Mexico, Viacheslav V. Kalashnikov, Nataliya I. Kalashnykova, Vladik Kreinovich

We examine a bilevel optimization problem where the upper level decisions are made by the airline's management governing the proportion of preferred boarding passes and the price of the latter. The economy class passengers seek the Nash equilibrium at the lower level of the model venturing to maximize their payoff functions thus generating a Markov chain's transition matrix. The steady-state probabilities of the chain are used at the upper level to define the groups into which the economy class passengers are partitioned. The existence of solutions to the problem is established, and simple numerical experiments are made. Important conclusions and bypass practical recommendations can be developed.

69 - Analysis of Complete Information Disclosure Behavior of Pollutant Enterprises and Government's Supervision Based on Evolution Game Theory

Dan Luo, Student, Tongji University, Shanghai,China, China, 1550724@tongji.edu.cn

The evolution game model is established to analyze the influence of complete information disclosure subsidy rate, failure compensation rate, penalty rate, central subsidy to local government and public attention on this system.MATLAB is used to directly show the results.The research shows that a certain level of reward and subsidy helps to form a trust relationship between enterprises and government.The central reward to local is helpful to the rapid stability of the system.The increase of the penalty rate to eliminate enterprises with incomplete disclosure will accelerate the system. The increase of social attention is conducive to the prudent decision-making of enterprises and governments.

70 - A New Scenario Resource for Integrated 1.5°C Research in the Context of Climate Change and Sustainable Development

Daniel Huppmann, International Institute for Applied Systems Analysis (IIASA), Vienna, Austria, huppmann@iiasa.ac.at

This poster presents the scenario ensemble of quantitative pathways compiled to support the assessment for the IPCC Special Report on Global Warming of 1.5°C (SR15). It also provides an overview of the suite of open tools to facilitate exploration and analysis of this resource and highlights how the tools were implemented following the FAIR principles for open, collaborative research.

71 - Data Intensive Industrial Asset Management for Distributed Energy Resources

Farhad Balali, PhD. Candidate, University of Wisconsin-Milwaukee, Milwaukee, WI, United States, mbalali@uwm.edu, Hamid Seifoddini, Adel Nasiri

The main purpose of this study is to develop an analytical methodology to assess the reliability based on the data-driven degradation model. Auto-Regressive degradation models are considered in a state-space environment. Ther proposed predictive models of Asset Management is able to predict the failure in order to schedule the optimized maintenance orders and replacement schedules. Failure events are usually defined as a point of the time when the degradation profile hits the critical limit. Therefore, this study seeks to present an exact formulation of the data-driven models of Asset Management based on the time-series degradation estimates.

72 - High Accuracy in Ultrasonographics Patterns Detection over 30.000 Images in Lateral Elbow Tendinopathy with Artificial Intelligence

Guillermo Droppelmann, Research Director, MEDS Clinic, Santiago, Chile, guillermo.droppelmann@meds.cl, Manuel Tello, Cristóbal Greene, Julio Rosales, David Prieto, Felipe Feijoo

Ultrasound diagnostic techniques have shown moderate accuracy in objectively diagnosing tendinopathies. We develop a machine and deep learning model and show that they have higher discriminatory accuracy than standard diagnostic methods based on ultrasound exams. The models are built and tested using 30.977 ultrasounds images with lateral elbow tendinopathy.

73 - Avoidable Acute Hospitalizations During the Early Phase of Post-Acute Care? Opportunities to Drive Preventive Strategies and Reorient Care

Jakka Sairamesh, CapsicoHealth, Inc, San Francisco, CA, United States

Over 1 in 9 patients are hospitalized from home health settings within a 60-day episode of care. With Value based care being promoted by CMS (e.g. BPCI, BPCI-A and CJR) and Commercial payors, there is a growing trend to discharge patients to home-health care with the right support. CMS has launched initiatives over the past few years to reduce unplanned 30-day readmissions to hospitals to tackle the 17 Billion in 30-day readmissions costs per year. Our data for analyses includes Medicare claims over a 2-year period from 2016-Q1 to 2018-Q1. We conclude that identification of hospitalization risk will help target and orient the appropriate care to the patients at home.

74 - Evaluating the Structural and Temporal Aspects of Responses to a Short Daily Wellness Questionnaire

Michael Tolston, Ball Aerospace and Technologies, Fairborn, OH, United States, mtolston@ball.com, Maegan O'Connor, Nickolas Mackowski, Samantha Leyh, Adam Strang

Short daily wellness questionnaires given as part of a controlled physical training program are rarely evaluated for simple factor structure or to see how that structure might change over time. Further, different analyses may be required to capture how individuals are related compared to how training sessions are related. In this work, we show that partial triadic analysis—a generalization of principal components analysis designed for repeated measures data—of responses to a daily-administered wellness questionnaire addresses this and reveals different structures for individuals and training sessions.

75 - Exploiting Vulnerabilities of Load Forecasting

Yize Chen, University of Washington, Seattle, WA, United States, yizechen@uw.edu

Load forecasting plays a critical role in the operation and planning of power systems. By using input features such as historical loads and weather forecasts, system operators build forecast models to guide decision making in commitment and dispatch. We study the vulnerability of a class of load forecasting algorithms, and propose data injection attack that require minimal assumptions on the ability of the adversary. The attacker does not need to have knowledge about the load forecasting model or the underlying power system. Surprisingly, standard load forecasts are quite vulnerable to the designed black-box attacks, and attacker could cause significant and targeted damages to system operations.

76 - The Application of Semi-supervised Learning for Breast Cancer Subtyping

Asala Erekat, Graduate Research Associate, State University of New York at Binghamton, Binghamton, NY, United States, aerekat1@binghamton.edu

In healthcare getting a fully labelled dataset is cumbersome and expensive. Most of the current studies in genomics have focused on supervised or unsupervised learning. Using supervised learning on a high-dimensional small labelled dataset is prone to overfitting, while using unsupervised learning on a large unlabeled dataset might lead to complications in interpreting the clusters specifically when the models yield low accuracy. Hence, this research tackles the mentioned problems by utilizing semi-supervised learning on a mix of labelled and unlabeled multivariate genomics data to help identify different breast cancer subtypes with high accuracy.

77 - Optimal Scheduling of Community-based Social Workers to Mitigate Opioid-related Overdose

Carolina Vivas-Valencia, Purdue University, West Lafayette, IN, United States, Nan Kong, Yunan Liu, Paul Griffin

We are currently in a public health crisis for opioid use disorder (OUD). OUD has become a challenging mental health issue, where people will benefit the most from an integrated system of care. However, in many cases, psychosocial services cannot be ensured due to scheduling inconvenience and resources availability. In this study, we formulate an optimal scheduling model for social workers from a community network that provides behavioral nudging to mitigate opioid-related overdose and relapse. We conduct a case study using data from the Indiana Family and Social Services Administration to validate the need for the optimal scheduling to engage OUD users in community-based support.

78 - Current Challenges in Development of a Survival Analysis Data Mining Study

Hamidreza Ahady Dolatsara, Clark University, Worcester, MA, United States, hamid@auburn.edu, Fadel Mounir Megahed, Ying-Ju Tessa Chen

This study highlights the issues and challenges that are associated with the development of a data mining (DM) study in the transplantation field. The UNOS dataset was investigated for the development of a data mining study to predict survival of patients within one year after heart transplantation surgery. CRISP-DM (CRoss Industry Standard Process for Data Mining) was adopted as the outline of the DM based survival analysis.

79 - Modeling an Energy System Model for the Road Transportation Sector to Analyze Greenhouse Gas Reduction Policies in South Korea

Hansung Kim, Pohang University of Science and Technology (POSTECH), Pohang, Gyeongbuk, Korea, Republic of, Daiki Min, Dong Gu Choi

South Korea needs to reduce greenhouse gas (GHG) emissions by 37% compared to the BAU scenario by 2030. The road transportation sector is one of the major sectors that consume a large amount of energy. The Korean government is planning various policies to reduce GHG emissions in the sector such as the dissemination of eco-friendly vehicles. In this study, we model a bottom-up energy system for the road sector and analyze the effects of various policies. The model comprises the demand projection module, modal shift module, vehicle stock module, and scrappage module. Based on the model, we analyze the amounts of GHG reduction by 2050 from four major policies.

80 - Optimal Capacity Planning of Generation System Integrating Uncertain Solar and Wind Energy with Seasonal Uncertainty

Heejung Park, Assistant Professor, Kyungpook National University, Daegu, Korea, Republic of, h.park@utexas.edu, Ross Baldick

We present a generation capacity planning model for integration of utility-scale wind farms and grid-connected solar photovoltaic (PV) generation systems via multi-stage stochastic programming. A multi-stage scenario tree for available wind power, electric load, and solar irradiance is constructed with nine stages for a year. Random samples for wind, load, and solar irradiance are generated using Gaussian copula which represents correlation between random samples. Environmental energy policies to control carbon dioxide emissions and increase energy generation from renewable sources are implemented, and the resulting generation capacity mix is investigated.

81 - Complication of Patients undergoing Living Donor Nephrectomy Using Clavien-dindo Grades: An Analysis of HCUP-NIS Data (2008-2015)

Maryam Soltanpour Gharibdousti, PhD Candidate, Binghamton University, Binghamton, NY, United States, msoltan1@binghamton.edu, Mohammad Khasawneh, Amy L. Friedman

The predictors of early clinical outcomes following living donor nephrectomy are determined. A comprehensive analysis, using 2008-2015 discharge data from the Healthcare Cost and Utilization Project Nationwide Inpatient Sample, was performed. Cases were identified by ICD-9 codes. Clinical outcomes were analyzed with regard to patient and provider characteristics using machine learning tools. Using the ICD-9 codes provided for each patient, we used the Clavien-Dindo Grades to classify patients based on their level of complications after surgery. Having Grade III or higher is considered as major complications and gradient boosting algorithms is used to predict the complication level.

82 - Scenario Selection for Iterative Stochastic Transmission Expansion Planning

Faezeh Akhavizadegan, Iowa State University, Ames, IA, United States, Faezeh.akhavizadegan@gmail.com, Lizhi Wang

Reliable transmission expansion planning is a critical part of a power system development due to existing numerous sources of uncertainty. We develop a new approach to selecting a small number of high-quality scenarios as representative of all scenarios. A bilevel optimization model was used to generate reasonable scenarios and regression model was used to estimate social welfare of scenarios to select high-quality scenarios. The US Eastern and Western Interconnections power system was used as the case study to select ten high-quality out of one million scenarios for two transmission plans.

83 - An Evolutionary Game Theory Approach to Comparing the Effect of Alternative Policy Instruments on Electric Vehicles

Camila Apablaza, PhD Student, Georgia Tech, Atlanta, GA, United States, capablaza@gatech.edu, Valerie Thomas

The widespread adoption of electric vehicles (EVs) is an important aspect of the efforts for curbing carbon emissions. However, is it not clear what type of policy instruments are more effective and efficient in achieving a high adoption of electric technologies among vehicles owners. This study uses an evolutionary game theory approach to compare the effect of adopting policies aimed at increasing EVs adoption through market-oriented instruments such as subsidies and research and development investments in technology improvements. We simulate random interactions in the network of private and public stakeholders that are relevant to the consumers' decision-making process.

84 - Biorefining and Machine Learning: Towards a Universal Model of Wood Deconstruction

Riley H. Ballachay, Undergraduate Research Assistant, The University of British Columbia, Vancouver, BC, Canada

Hemicellulose has diverse applications in the industry. Industrial use of hemicellulose often requires that the polymer be hydrolyzed into constituent oligomers and monomers. Models exist to predict sugar yield during hydrolysis, but none can be applied to varied feedstock and operating conditions. Machine learning is used to develop a universal model to predict xylose yield. Two models (ordinary least squares regression and artificial neural networks) are assessed and compared to a simplified kinetic model. In total, 2048 data points were mined from the literature and used to create the models. The machine learning models are shown to perform better than the kinetic model.

85 - Multiple Objective Land-use Change Optimization for Biofuel Feedstock Production

Ana C. Cram, Research Assistant, University of Texas at El Paso, El Paso, TX, United States, accram@miners.utep.edu, Heidi Taboada, Jose Espiritu

This research proposes a coupled modeling framework to optimize land use allocation for biofuel feedstock production. This framework uses the Soil and Water Assessment Tool to estimate the potential effects of Land-Use Change on soil and water quality, and the Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation model to quantifies the emissions produced from cultivating biofuel feedstock to its conversion to bioethanol. Land use allocation is optimized using a Multi-Objective Genetic Algorithm, maximizing biomass yields while minimizing environmental impacts.

86 - A Personalized Recommender System for Education

Chul Kim, Baruch College, New york, NY, United States, William Rand, Pallassana K. Kannan

We develop a machine-learning-based personalized recommender system for such a context. The proposed recommender system extracts three vital educational factors of efficiency, importance, and diversity in lieu of the ratings by utilizing the learning outcomes and hierarchical relationships among learning objects. Both supervised and unsupervised machine learning methods are applied. We implement the proposed recommender system in an online adaptive learning platform for K-12 mathematics education. Analyzing one year of data generated from a natural experiment, we find empirical evidence of the efficacy of the proposed system in improving learners' proficiency.

87 - Analysis of Higher Education Financing Trends and Options

Cindy Stuch, University of Michigan-College of Engineering, Canton, MI, United States, cstuch@umich.edu

The landscape of higher education has changed greatly in the last 35 years. Enrollment trends have gone down after peaking seven years ago and student debt has risen to an all-time high at over 1.5 trillion dollars. Higher education institutions, mainly private for-profit colleges, are increasingly going out of business. We use logistic regression to map the landscape of higher education and predict the likelihood of a school failing. We also present a system dynamics model to evaluate the impact of policies on different types of higher education institutions.

88 - Blockchain Business Model: Value Creation and Appropriation

H. Michael Chung, Professor and Director, California State University-Long Beach, Long Beach, CA, United States, hm.chung@csulb.edu

This study focuses on how blockchain and its applications create and appropriate value, impact institutional governance, and eventually provide opportunities to develop new business models. The paper analyzes disintermediation in organizational business processes and value creation from economic and organizational perspectives. The research analyzes how value would be captured and appropriated, as well as how institutional governance would further evolve in the future. We address why and how of disintermediation or its variations, and its occurrence in centralized governance. Then we develop a theoretical framework encompassing the above discussion.

89 - Agent-based Modeling of Client Preferences at Food Pantries

Benjamin F. Morrow, North Carolina A&T State University, Greensboro, NC, United States, bfmorrow1@aggies.ncat.edu

Last year, the Feeding America network distributed more than 3.6 billion meals through food pantries and meal programs. Traditional food pantries have several disadvantages including overstocking of certain foods, increased food waste, and negative psychological effects on the clients. This study will use agent-based modeling to model client preferences, food donations, and food distribution. One of the key goals of this research is to use agent-based modeling to compare the client choice food distribution model to the traditional food pantry distribution model to determine which food distribution model is more efficient.

90 - Simulating Diverse Eastern Gamagrass Ecotypes in Texas

Angela Avila, University of Texas at Arlington, Arlington, TX, United States, angela.avila2@mavs.uta.edu, Sumin Kim, Jianzhong Su, Amber Williams, Jim Kiniry

Eastern gamagrass is a valuable, productive native grass that ranged from eastern and southern U.S. It is highly palatable, high quality forage and produces high yields on marginal land due to excess moisture. This study summarizes measurements of 5 ecotypes collected from various locations in Texas and Oklahoma and growing in Temple, TX. Measurements are made for plant parameters for the ALMANAC model. The model is applied to a diversity of soils and environments, looking at productivity of the 5 ecotypes and examined for determining which ecotype is optimum for these different environments.

91 - A Discrete Event Simulation Based Approach to Maximize the Piston Throughput for a Manufacturer of Diesel Engines

Samaneh Davarzani, Mississippi State University, Starkville, MS, United States, Morteza Nagahi, Mehrnaz Noroozi Esfahani

The auto manufacturing system is a complex system which exhibits conditions of uncertainty, ambiguity, and emergence. Using a data-driven discrete event simulation approach, this paper portrays to identify and to optimize key process input variables to the production output for a manufacturer of diesel engines in Mississippi, USA. The outcome of the analysis of current system exhibits that deploying a few numbers of carts and also unbalanced process times results in bottlenecks which decreases the systems' throughput substantially. An analysis of optimal solutions, the best balance between input variables, is demonstrated, and followed by recommendation and avenues for future research.

92 - A Library of Wiedemann 99 Car-following Model Parameters

Amir Ghiasi, Leidos, Inc., McLean, VA, United States, amir.ghiasi@leidos.com, David Hale, Zhitong Huang

Recent studies suggest that ignoring the correlations between different car-following model parameters results in inaccurate representation of driving behaviors. This study calibrates the Wiedemann 99 car-following model parameters to individual drivers using a subset of Next Generation Simulation (NGSIM) trajectory dataset. The results show that some model parameters are significantly correlated. This methodology enables us to develop a library of Wiedemann 99 car-following model parameters that could address the heterogeneity nature of driving. With this library, people's driving styles are further studied and categorized into three levels: aggressive, moderate, and conservative.

93 - Future Aviation Crew Planning

Burak Cankaya, Embry Riddle Aeronautical University, Daytona Beach, FL, United States, Aaron Glassman, Bulent Erenay

This research poster will contribute to the crew resource planning for multi fleet aviation companies. The crew training plannings will be optimized to serve the current fleet needs and future crew need of the aviation companies.

94 - Electric and Autonomous Vehicles Technology in Private and Shared Mobility Systems with Multiclass Users

Harprinderjot Singh, Michigan State University, East Lansing, MI, United States, singhh24@msu.edu, Mehrnaz Ghamami

Autonomous Vehicles (AV) are known to increase vehicle miles traveled and congestion, which affects energy consumption and emission production. Electric Vehicles (EV) with zero running emissions can compensate for a part of these losses. However, the limited range of current EVs and low density of charging stations can hinder the adoption of these vehicles. A modeling framework is developed to estimate optimum fleet configuration resulting in minimum system cost, considering different tradeoffs in adoption EVs and AVs, in a private and shared mobility system with multiclass users.

95 - A Many-to-Many with Split Load Routing Problem

Sudheer Ballare, University of Illinois-Chicago, Chicago, IL, United States, Jane Lin

The rise of e-commerce and same-day delivery service may lead to negative externalities. One of the emerging urban last mile delivery paradigms is the so-called microhubs with crowdshipping (M+C). In particularly, the truck routing among microhubs is a Many-to-Many with Split Load routing problem (MMSLRP). This study presents and evaluate a solution method of MMSLRP by comparing with exact solution methods and existing heuristics. Furthermore, performance of M+C is compared with the traditional hub-and-spoke delivery service paradigm in terms of number of trucks and crowdshippers dispatched, fuel usage, vehicle miles traveled, and operating costs.

96 - Dynamic Platooning for Mixed Traffic Flow of Human-driven and Autonomous Vehicles

Jia Li, Texas Tech University, Lubbock, TX, United States, jia.li@ttu.edu, Lidong Wu

This research proposes a dynamic strategy to enhance platooning formation in mixed traffic flow of human-driven vehicles and automated vehicles. When no control is imposed, platooning between automated vehicles (AVs) relies on spontaneous peer-to-peer matching in traffic flow, which is random, myopic, and not efficient. We develop a dynamic platooning mechanism to address the problem, which is centered on customized information dissemination and incentive design for different subgroups of AVs. We provide analytical insights into the proposed strategy along with simulation experiments.

97 - Do Transportation Network Companies Reduce Public Transit Use in the U.S.

Narendra Malalgoda, Graduate Research Assistant, North Dakota State Universiy, Fargo, ND, United States, narendra.malalgoda@ndsu.edu, Siew Hoon Lim

The rise of transportation network companies (TNCs) has revolutionized urban transportation across the globe. Using top 50 U.S. agency-level data from 2007 through 2017, this study examines the effect of TNCs and transit effectiveness on public transit ridership in the U.S. We find that (1) transit effectiveness of both bus and rail transits declined over the study period (2) TNC availability significantly increased rail transit ridership in 2014 and 2015, but the positive effect subsided in 2016 and 2017 (3) transit effectiveness was highly significant for rail transit, and when examining its effect year-by-year, rail transit effectiveness trumped TNCs availability.

98 - Deep Adaptive Learning for Safe and Efficient Navigation of Pedestrian Dynamics – Airport Evacuation

Nigel Pugh, PhD Student, North Carolina A&T State Univeirsity, Greensboro, NC, United States, John Park, Srish Namilae, Dahai Liu, Pierrot Derjany

An efficient and safe evacuations of passengers is important during emergencies. A congested route would delay the evacuation performance; hence decision-making is needed to optimally distribute passengers. Previous evacuation planning studies focused on either simulation of realistic human behaviors or simple route planning, the best route decisions with several intermediate decision-points, has not been considered. We develop an optimal navigation model for evacuation path planning to minimize the total evacuation time composed of arrivals at intermediate decision points while considering the influence on other passengers based on the social-force model.

99 - An Epidemiological Modeling Approach to Fuel Shortages During Hurricane Evacuations

Sirish Namilae, Associate Professor, Embry-Riddle Aeronautical University, Daytona Beach, FL, United States, namilaes@erau.edu, Sabique Islam, Scott Parr, Dahai Liu, Richard Prazenica

High-volume mass evacuations have led to fuel shortages lasting several days during several recent hurricanes. While news reports mention fuel shortages in many past hurricanes, the crowd-sourced platform Gasbuddy has quantified the shortages in the recent hurricanes. Analysis of this data suggests the characteristics of an epidemic. We present an epidemiological model for hurricane fuel shortage and devise an optimal control strategy to mitigate the epidemic. Results show a direct correlation between evacuation traffic volume and fuel shortages. The control strategy is effective in estimating the level and duration of intervention required to mitigate the fuel shortage epidemic.

100 - Estimating Multiclass Dynamic O-D Demand Through a Forward and Backward Algorithm on Computational Graphs

Wei Ma, Carnegie Mellon University, Pittsburgh, PA, United States, weima@cmu.edu, Zhen Qian

Transportation networks are unprecedentedly complex with heterogeneous vehicular flow. Conventionally, vehicle classes are considered by vehicle classifications (such as standard passenger cars and trucks). Provided with some observations of vehicular flow, how to estimate the multi-class spatio-temporal vehicular flow, in terms of time-varying Origin-Destination (OD) demand, remains a big challenge. This paper solves this problem by proposing a computational graph with tensor representations of spatio-temporal flow and all intermediate features involved in the MCDODE formulation. The proposed framework is examined on a small network as well as a real-world large-scale network.

101 - Air Traffic Noise Pollution Management with ADS-B and GIS: State of Art Review and Initial Results in UAE

Young-Ji Byon, Khalifa University of Science and Technology, Abu Dhabi, United Arab Emirates, youngji.byon@ku.ac.ae, Tadahiro Kishida, Maryam Abdulqader Alkhalifi

Advancements in 3-D GIS computing complemented by newly available ADS-B signals from commercial airplanes can provide a platform for monitoring air traffic noise near airports, by utilizing embedded information including 3-D location, aircraft type, speed etc. Due to aggressive developments in airport expansions in UAE, associated issues with the air traffic noise are also expected to arise. This research develops an air traffic noise management framework utilizing ADS-B and GIS for airports in UAE along with a state of art review on a topic of airport noise monitoring.

102 - Machine-learning-based Vehicle Delay Prediction at Signalized Intersections

Behnoush Garshasebi, Former Graduate student at University of Illinois at Urbana Champaign, Urbana, IL, United States

Measuring performance at signalized intersections is crucial in planning for efficient traffic operations by optimizing the traffic signal timing plans. Delay is among the critical performance measures for signalized intersections. Delay calculation from field data is time-consuming and predominantly relies on tedious manual counting of vehicles and post-analysis, making quick decision-making difficult for practitioners. Thus, a more efficient way of delay calculation is needed. As a contribution to this field, we propose a Random Forest (RF) predictive model for fast and straightforward vehicle delay prediction at signalized intersections.

103 - Does Being Socially Responsible Correlate with Traffic Congestion in Metropolitan Areas in the United States?

Bukola Bakare, North Dakota State University, Fargo, ND, United States, bukola.bakare@ndsu.edu, Joseph Szmerekovsky

Traffic congestion is a critical environmental event with a direct adverse impact on people's health and productivity. This study investigates the level of socially responsible Fortune 500 corporations in major cities in the United States. Through interviews conducted by the authors, qualitative analysis is used to study one of the top metropolitan areas to capture and explore how traffic congestion trends and corporate social responsibility ratings apply on a local level. This study presents the results of the qualitative analysis.

104 - Column Generation Approach for Train Scheduling and Rolling Stock Circulation Plan Considering Skip-stop Patterns in Urban Railway Network

Bum Hwan Park, Korea National University of Transportation, Uiwang, Korea, Republic of, bumhwan.park@gmail.com

In recent years, in order to reduce the congestion and travel time of passengers, there is a great interest in the construction of a train schedule in which trains that stop at all stations and trains that stop only at major stations are mixed. This study is a study on the optimization model for constructing train schedule and circulation plan simultaneously in consideration of various stop patterns in urban railway. To this end, this study presents an optimization model based on the path flow variable defined in the time-space network, proposes a column generation based heuristic to solve it, and presents the application results for Seoul Line 9.

105 - Analysis of the Road Freight Structure Characteristics in Sichuan Province Based on the Data from O2O Freight Platform

Xinyuan Li, Southwest Jiaotong University, Chengdu, China, 505336717@qq.com, Mi Gan, Qiujun Qian, Dandan Li

Based on O2O freight platform data, this paper studies the freight structure of Sichuan Province. The research focuses on the road freight structure of Sichuan Province. First of all, to understand the current situation of Sichuan road freight, through data mining and data visualization of freight volume demand structure, cargo type structure analysis. Then the relationship between logistics industry and regional industrial structure is studied by grey correlation method, and the degree of correlation between logistics industry and regional industrial development in Sichuan Province is obtained.

106 - Identification of Empty Driving Behavior Using Truck Trajectory Data

Dandan Li, Southwest Jiaotong University, Chengdu, China, 2016210837@my.swjtu.edu.cn, Mi Gan, Wenchang Zhang

This paper aiming to using the data from the online freight exchange (OFEX) platform to identify the empty driving condition of trucks. OFEX platform collects data through the truck drivers' mobile phone APP, which contains not only positioning information, but also the online behavior of drivers. The main method in this paper is to use the trajectory data and online data of 2000 drives, combined with POI information to construct a clustering algorithm to extract the Origin-Destination (OD) of the truck, so that the trips can be obtained, and then using the driver online behavior data and other information to identify the empty driving condition of the truck in a trip.

107 - Freight Mode Mining Based on GPS Data of Trucks

Qiujun Qian, Southwest Jiaotong University, Chengdu, China, Yuling Deng, Mi Gan, Dandan Li

This paper takes the GPS data obtained by the road freight platform as the data source, establishes the model through relevant algorithms, analyzes and studies the freight modes and basic characteristics, and proposes the trajectory-based freight mode selection method. the Hausdorff distance is used to measure the trajectory similarity from both time and space. The DBSCAN algorithm is used for trajectory clustering, and found that the current vehicle trajectory can be divided into three modes: reciprocating, ring and hub-and-spoke.

108 - Optimal Deployment of Autonomous Buses in Bus Service Operation

David Z.W. Wang, Associate Professor, Nanyang Technological University, Singapore, Singapore

This paper proposes a multi-stage model for optimizing the deployment strategy in which the conventional buses are sequentially replaced by the autonomous vehicle buses (AvB). Specifically, we study which lines should be deployed with AvB at each planning stage. In this work, passengers' adoption attitudes towards autonomous buses are explicitly considered and the transit assignment problem is formulated as a multi-class UE model. To forecast the evolution of the adoption rate, we apply a diffusion model. We propose a multi-stage model for the optimal replacement strategy that minimizes the total travel cost during the planning periods. A hybrid solution method is used to solve the model.

109 - Shuttle Bus Solution to Keep the City Moving

EunSu Lee, Associate Professor, New Jersey City University, Jersey City, NJ, United States, elee3@njcu.edu, Eve Anderson, Bui A. Thy

The Hudson-Bergen Light Rail (HBLR) shuts down the West Side Avenue branch temporarily for planned sewage pipeline work. New Jersey Transit discussed how it would provide alternate means of transportation using shuttle buses, but this shutdown will have a major impact on the community. This study evaluates scenarios of cost effective and commuter efficient resource assignment and scheduling of the shuttle buses with local light rail systems. For discussing scenarios, the study developed integer linear programming (ILP).

110 - Scattered Storage for E-commerce Warehouses

Harol Mauricio Gamez Alban, University of Antwerpen, Antwerp, Belgium, mauricio.gamezalban@uantwerpen.be

Please check the mobile app for this abstract.

111 - Option of Urban Function Patterns of Railway Integrated Passenger Transport Hub Based 0n TOPSIS

Siyu Tao, School of Transportation and Logistics, Southwest Jiaotong University, Chengdu, China, 15221309@qq.com
Siyu Tao, National United Engineering Laboratory of Integrated and Intelligent Transportation, Chengdu, China, 15221309@qq.com, Tao Feng, Xinmei Chen, Anjun Li, Qiyuan Peng, Xin Xie

The commercial development pattern of the railway integrated passenger transport hub is faced with the problems of how to opt the type of real estate & determine the size of the business volume. According to the option of combination pattern of the urban functions, the entropy weight method-extended TOPSIS evaluation model is proposed. The advantage of this model is that an evaluation index system can be established according to the economic development, population scale & traffic status of the city. The integrated urban function is adapted to local conditions with strong feasibility & avoiding severe congestion.

112 - Research on the Use Arrangement of Waiting Room in Railway Station

Siyu Tao, School of Transportation and Logistics, Southwest Jiaotong University, Chengdu, 610031, China, siyu.tao@okstate.edu, National United Engineering Laboratory of Integrated and Intelligent Transportation, Chengdu, China, siyu.tao@okstate.edu
Siyu Tao, National Engineering Laboratory of Integrated Transportation Big Data Application Technology, Chengdu, China, siyu.tao@okstate.edu, Xin Xie, Tao Feng, Yuhong Liu

The waiting room of the railway station is the last place for passengers to stay for the longest time, check tickets before boarding, and where aggregation density is the highest. When special circumstances arise, the use arrangement of the waiting room is disrupted, which is more likely to lead to chaos. From the view of the use arrangement of waiting room, the use arrangement of waiting room is mainly arranged by the staff according to their previous work experience, which has great room for improvement. An optimization model for the use arrangement of waiting rooms was established to makes the use of waiting rooms more balanced and the passenger walking distance the shortest.

113 - Analysis & Empirical Researchon the Status of China's High-speed Railway Network

Xuan Wang, Southwest Jiaotong University, Chengdu, China, 409897691@qq.com

The structure of the network is closely related to its function. Understanding network characteristics can help us better understand network behavior, thereby improving network performance and providing a theoretical basis for managing the network more effectively. Empirical research shows that high-speed railway network, as a concrete form of network, has the characteristics of scaleless network. By studying the structure of China's high-speed railway network, we can explain the operation mode ofthe system based on the network, and provide theoretical basis for the construction of the new high-speed railway stations by analyzing the factors affecting the connection of stations.

114 - The Effects of Review Comprehensiveness on Review Helpfulness

Yi Liu, Associate Professor, Rennes School of Business, Rennes, France, yi.liu@rennes-sb.com, Lakshmi Narasimha Raju Vuddaraju

Consumer's evaluation of online review helpfulness has been found to be affected by the length of the review content. However, review length could not fully represent its comprehensiveness. This study aims to investigate the review comprehensiveness by mining the aspects each review covers, and examine how review comprehensiveness influences its helpfulness. By analyzing online restaurant reviews from one of the most popular restaurant review platforms, it finds that review comprehensiveness positively relates to review helpfulness. In addition, review valence negatively moderates the effect of review comprehensiveness on its helpfulness.

115 - A Lossless Compression Method Based on Dictionary Coding for Traffic Trajectory Data

Jiannan Mao, Southwest Jiaotong University, Chengdu, China, Lan Liu, Weike Lu, Yihan Wang, Yuting Chen

To reduce the size of trajectory data for convenient transmission, a lossless compression method, named Lossless Traffic Trajectory Data Compression (LTTC) is proposed based on the dictionary coding method. The dataset is pre-processed by the clustering and code mapping strategy. Then a Substituted Run-length LZ (SRL) algorithm for lossless compression is established to further deal with the pre-processed data. Subsequently, a 0-1 programming model is employed to optimize the dictionary resources in SRL algorithm. The proposed method is validated on the GPS trajectory data provided by Microsoft Geolife project and shows a high compression ability and strong real-time operability.

116 - Research on the Impact of Industrial Development and Logistics Demand in County Cities under the Perspective of Spatial Relevance: A Case Study of Leshan City

Xiaozhen Deng, National United Engineering Laboratory of Integrated and Intelligent Transportation, Chengdu, China, dengxiaozhenswjtu@163.com, Southwest Jiaotong University, Chengdu, China, dengxiaozhenswjtu@163.com, Si Chen, Yinying Tang

Under the background of the new urbanization, industrial and the satisfaction of logistics demand of County cities are affected by related industries of themselves and adjacent cities. This paper studies the relationship between the three major industries and logistics production in County cities from the perspective of spatial correlation, the results show that the secondary industry has gradually become core industry of Leshan county cities, the positive correlation between logistics and secondary and tertiary industries is higher than that of primary industry.

117 - A Multi-stage Stochastic Programming Model for Relief Distribution Considering the State of Road Network

Zhijie Dong, Texas State University, San Marcos, TX, United States, sasha.dong@txstate.edu, Shaolong Hu

Prepositioning of relief supplies is an important aspect of disaster operations management that aims at decreasing the response time by advancing procurement and storage of needed supplies. In this paper we consider commodity life-time period with the related costs in keeping the commodity and removing it from the storage when it is close to expiration. We develop a multi-stage stochastic programming model for prepositioning of relief supplies, which provides relief agencies insight on how to have dynamically control inventories due to uncertain demands when disasters occur.

118 - A Two-stage Stochastic Integer Programming Approach for Truckload Trucking Problem

Xiandong Li, ZhiCang Technology, Beijing, China, lixd@heptax.com, Junchao Ma, Zhiyu Zhang, Zhiqiang Jiang, Wanfeng Yan

Truckload trucking problem, aims to solve a simple truck-to-load matching operation, there exist a vast literature for both myopic and non-myopic model. These models are often used as decision-making or analytic simulation tool. In this work, we develop a two-stage stochastic integer programming model to fulfill the needs of daily/weekly simulation in our company. A discrete time multicommodity network flow formulation is adapted as our second stage problem to have a precise reposition time step. We solve this problem by integer L-shaped method and adopt sample average approximation approach as our Monte Carlo method.

Monday, 1:30PM - 3:00PM

■ MC01

CC- Room 201

Data Mining and Machine Learning in Healthcare

Sponsored: Data Mining

Sponsored Session

Chair: Emisa Nategh

1 - Learning When-to-treat Policies

Stefan Wager, Stanford University, Stanford, CA, United States

Many applied decision-making problems have a dynamic component: The policymaker needs not only to choose whom to treat, but also when to start which treatment. For example, a medical doctor may see a patient many times and, at each visit, need to choose between prescribing either an invasive or a non-invasive procedure and postponing the decision to the next visit. We propose a new, robust approach to this problem that is practical for policy optimization and does not need any structural (e.g., Markovian) assumptions.

2 - Detecting Early Stage Cancer using Liquid Biopsy

Jackie Baek, MIT, Cambridge, MA, United States, baek@mit.edu, Deeksha Sinha, Andrew A. Li, Vivek Farias

The cost of DNA sequencing has fallen 10,000x in the last ten years, and we are finally in sight of the silver bullet for cancer screening: an early-stage blood test. As sequencing can now be performed affordably on a tiny fraction of a genome, what remains is a massive variable selection problem. We provide an efficient algorithm, based on a decomposition at the gene level, that scales to full genomic sequences across thousands of patients. We contrast our selected variables against DNA panels from two recent, high-profile studies and demonstrate that our own panels achieve significantly higher sensitivities at the same cost, along with accurate discrimination between cancer types for the first time.

3 - A Value of Information Approach to Designing Sequential Clinical Trials for Personalized Health Care

Andres Alban, INSEAD, Fontainebleau, France, Stephen E. Chick, Spyros Zoumpoulis

We formulate a model of a clinical trial in which the patient population can be categorized in a small set of subpopulations. The goal of the trial is to determine which subpopulations can benefit from which treatment. We apply expected value of information policies for the setting in which patients with different observable characteristics arrive stochastically, and we must decide the treatment to provide to each patient.

4 - Quantile Regression for Healthcare Analytics: A New Computational Trick

Donald Lee, Goizueta Business School, Emory University, Atlanta, GA, 30322, United States, donald.lee@emory.edu, Peter Aronow

In forecasting healthcare costs, the quantity of interest is typically not the conditional mean given covariates. Rather, conditional quantiles obtained through quantile regression provide richer distributional information. However, applying machine learning algorithms like XGBoost to the quantile regression loss function is a computational challenge because the loss is inherently jagged. In this talk, we discuss an interesting discovery on how the quantile loss function can be replaced by the singular limit of a sequence of smooth loss functions. These smooth functions can then be used in lieu of the quantile loss in ML algorithms that require second order derivatives, such as XGBoost.

5 - Leveraging Multivariate Time Series of Claims Data Using Deep Learning Methods for Healthcare Cost Prediction

Mohammad Amin Morid, Santa Clara University, Santa Clara, CA, United States, Olivia R. Liu Sheng, Kensaku Kawamoto, Samir Abdelrahman

This study attempted to leverage individuals' temporal data of healthcare claims for predicting their cost by learning their temporal patterns. To achieve this, we proposed using a convolutional neural network (CNN) to learn different temporal patterns from multivariate time-series data of patients. Three years of medical and pharmacy claims data were used. The data consisted of the multivariate time series of cost, visits and medical features that were shaped as images of patients' health status. Patients' images were given to a CNN method with a proposed architecture. The results showed that feature learning through the proposed CNN significantly improved healthcare cost prediction.

■ MC02

CC- Room 202

Online Learning: Theory and Practical Applications

Sponsored: Data Mining

Sponsored Session

Chair: Chaosheng Dong

1 - Generalized Inverse Optimization through Online Learning

Chaosheng Dong, University of Pittsburgh, Pittsburgh, PA, 15260, United States, Bo Zeng

Inverse optimization is a powerful paradigm for learning preferences and restrictions that explain the behavior of a decision maker, based on a set of external signal and the corresponding decision pairs. However, most inverse optimization algorithms are designed specifically in batch setting, where all the data is available in advance. As a consequence, there has been rare use of these methods in an online setting suitable for real-time applications. In this paper, we propose a general framework for inverse optimization through online learning. Specifically, we develop an online learning algorithm that uses an implicit update rule which can handle noisy data.

2 - Large Scale Markov Decision Processes with Changing Rewards

Adrian Rivera Cardoso, Georgia Institute of Technology, Atlanta, GA, United States, adrian.riv@gatech.edu

We consider Markov Decision Processes where the transition dynamics are known and fixed but the rewards may change in an adversarial manner. First, we provide an algorithm that achieves (almost) optimal MDP regret. Its per time-step computational complexity depends polynomially on the number of states and actions. We then extend our results to the large state-space setting. By parametrizing the set of stationary occupancy measures with a small number of features, we design an algorithm with per time-step computational complexity that depends polynomially on the number of features and provide similar regret guarantees.

3 - Sample-optimal Parametric Q-learning with Linear Transition Models

Lin Yang, Postdoctoral Research Associate, Princeton University, 321 Schoolhouse Rd, Princeton, NJ, 08831, United States, Mengdi Wang

Consider a Markov decision process (MDP) that admits a set of state-action features, which can linearly express the process's probabilistic transition model. We propose a parametric Q-learning algorithm that finds an approximate-optimal policy using a sample size proportional to the feature dimension K and invariant with respect to the size of the state space. We further exploit the monotonicity property and intrinsic noise structure of the Bellman operator, provided the existence of anchor state-actions that imply implicit non-negativity in the feature space. We augment the algorithm using techniques of variance reduction to obtain an optimal sample complexity.

4 - Balancing Relevance and Diversity in Online Bipartite Matching via Submodularity

Pan Xu, University of Maryland, A.V.W. Building, Department of Computer Science, University of Maryland, College Park, MD, 20742, United States, panxu0@gmail.com, John P. Dickerson, Karthik Sankararaman, Aravind Srinivasan

Online matching models capture lots of real-world problems including matching workers to firms, and advertisers to keywords. Current literature just focuses on maximizing the total relevance of the matching via a linear function but ignore the diversity (e.g., displaying a relevant but diverse set of ads). In this paper, we propose an Online Submodular Bipartite Matching problem, where the goal is to maximize a general monotone submodular function over the set of matched edges. This objective is general enough to capture both diversity and relevance. We propose novel algorithms that have provable guarantees and are essentially optimal when restricted to various special cases.

5 - An Optimally-Competitive Algorithm for Maximum Online Perfect Bipartite Matching with i.i.d. Arrivals

Mark Velednitsky, University of California, Berkeley, CA, United States, marvel@berkeley.edu, Dorit Simona Hochbaum, Quico Spaen

We present an optimally-competitive algorithm for maximum online perfect bipartite matching with i.i.d. arrivals. We are given a known set of workers, a distribution over job types, and non-negative utility weights for each pair of worker and job types. At each time step, a job is drawn i.i.d. from the distribution over job types. The job must be irrevocably assigned to a worker and cannot be dropped. The goal is to maximize the expected sum of utilities after all jobs are assigned. We introduce a 0.5-competitive, randomized algorithm and prove that 0.5-competitive is the best possible.

■ MC03

CC- Room 203

Novel Applications of Structural Approaches to Data Analytics

Sponsored: Data Mining

Sponsored Session

Chair: Bernardo F. Quiroga, Pontificia Universidad Catolica de Chile, Macul, Santiago RM, Chile

1 - Pennies from Heaven: The Impact of Free Bids on All-pay Auction Performance

Christopher Dalton Parker, Pennsylvania State University, University Park, PA, 16802, United States

The sunk cost fallacy is one possible reason why people to continue doing something after strict utility maximization suggests they should stop. The mechanisms of the sunk cost fallacy could be financial (spending more money on a project), temporal (a longer time between the start of the project and now), or emotional (exerting more effort on a project). In the context of an online auction-based retailer, we 1) disentangle the three components of the sunk cost fallacy, and 2) determine how the sunk cost fallacy impacts the auctioneer's profits. We do this with data from the company and complement the analysis with lab experiments.

2 - Structural Estimation of Auto Recalls

Ahmet Colak, Clemson University, Pendleton, SC, 29670, United States, Robert Louis Bray

Using a sample of 1M consumer defect reports and 15K component-level auto recalls, we study how the US government and automakers improve fleet quality via recalls. We use complaint text mining and structural econometrics to predict the likelihood of recall events. We also estimate the underlying government deterrence effects.

3 - Estimating Checkout Lines from Transaction Data

Marcelo Olivares, Associate Professor, Universidad de Chile, Santiago, Chile, molivares@uchile.cl

This research uses the Queuing Inference Engine (QIE, Larson 1990, Bertsimas & Servi 1992) to estimate checkout lines in supermarkets. The QIE requires as an input time stamps of each transaction, which are used to construct busy periods of the server when transactions are consecutive. In practice, transactions are never perfectly consecutive and they need to be approximate. This research uses a machine learning algorithm to detect busy periods, which is calibrated with a large scale manual data coding of queue lengths. The application is validate with a large scale empirical study and is currently been implemented in more than 200 stores by a large supermarket chain.

4 - Empowering Education with Crowdfunding: Empirical Evidence From California Public Schools

Manpreet Gill, Assistant Professor of Marketing, University of South Carolina, Columbia, SC, United States, Chen Zhou, Qiang Liu

In the past decade, crowdfunding has emerged in education as a social enterprise to empower public education. In this research, the authors investigate the role of crowdfunding in public K-12 education as an emerging alternative source for resource investment. In particular, they assess the impact of teacher-acquired instructional resources via crowdfunding on student academic achievement. Collating novel data from an education crowdfunding platform dedicated to public schools in the U.S and the California Department of Education at the school-subject-grade-academic year level, they find that teacher-acquired instructional resources via crowdfunding can effectively improve student academic achievement on average, while having a differential impact on students at different proficiency levels. Furthermore, the findings identify boundary conditions for this effect, in terms of the type of resources acquired by teachers (i.e., books and technology) and the subject for which the resources are used (i.e., English). This research provides rich implications for education administrators, crowdfunding platform managers, donors/investors in public education, and public school teachers.

5 - An Evaluation of Nonstandard Solutions to Weak Instruments under Endogeneity

Bernardo F. Quiroga, Faculty of Economics and Management Sciences, Pontificia Universidad Catolica de Chile, School of Management, Macul, Santiago RM, Chile, bfquirog@gmail.com

The performance of standard IV (instrumental variables) regression methods relies on the strength of the instruments. We evaluate several different nonstandard empirical strategies that work under the exclusive presence of weak IVs, achieving identification by using additional structural information to the problem. We provide a guide to their implementation for empirical scholars, discuss their pros and cons, and evaluate their relative performance.

■ MC04

CC- Room 204

Data Mining in Biological and Medical Research

Sponsored: Data Mining

Sponsored Session

Chair: Zhuqi Miao

1 - SNP Variable Selection by Generalized Graph Domination

Zhuqi Miao, Oklahoma State University, 345 Business Building, Oklahoma State University, Stillwater, OK, 74078, United States, zhuqi.miao@okstate.edu, Shuzhen Sun, Charles Chen

High-throughput sequencing technology has revolutionized both medical and biological research by generating exceedingly large numbers of genetic variants. However, the resulting datasets might lead to poor generalization capacity. Concerns include noise accumulated due to the large number of predictors, sparse information regarding the p>>n problem, and overfitting and model mis-identification resulting from spurious collinearity. In this study, we present a k-dominating set model that can provide a flexible and effective method for selecting informative SNPs

2 - A Framework to Address Missing Values Challenge in Secondary Datasets the Case of Parkinson'S Diseases

Saeed Piri, Assistant Professor, University of Oregon, Lundquist College of Business, 434 Lillis Business Complex, Eugene, OR, 97403, United States, spiri@uoregon.edu

Missing values are very prevalent in secondary datasets (e.g. Electronic Health Records (EHR)) and dealing with them is very challenging in data mining. In this study, we propose a new framework to address missing values challenge in analyzing datasets such as EHR, where many variables with high degrees of missingness are available. We apply our proposed framework to an imbalanced EHR dataset and use it to develop diagnostic models for Parkinson's disease. To enhance our models' accuracy, we applied synthetic informative minority oversampling (SIMO) algorithm to over-sample the minority class and used machine learning techniques such as random forest and logistic regression to develop our models.

3 - Seeds of Discovery, Gene Bank Genomics Meeting World's Challenges

Charles Chen, Oklahoma State University, Stillwater, OK, United States, charles.chen@okstate.edu

Achieving food security for all humanity appears to be an important but daunting challenge in the face of population growth, environmental degradation and accelerating climate variability. Gene banks operated by the Global Crop Diversity Trust hold high priority global collection of crops. The huge complexity of holdings and strategically use of the germplasm means that most of the would-be building blocks for new varieties remain on shelves when agricultural challenges are unprecedented. Encouraged by the advancement in DNA sequencing and predictive modeling, this presentation will review and discuss the footsteps it has taken in gene bank genomics, making it truly global in scope and impact.

4 - Augmenting Machine Learning with Statistical Testing: A Novel Method for Early Sepsis Prediction

Zeyu Liu, University of Tennessee, Knoxville, TN, United States, zliu65@vols.utk.edu, Anahita Khojandi, Xueping Li, Rishikesan Kamaleswaran

Sepsis is a life-threatening condition, with approximately 265,000 death per year in the U.S. Early prediction of sepsis is paramount to reducing mortality rate. In this work, we develop a sepsis prediction method using only a minimal set of physiological signals collected at the bedside. We first develop a machine learning model to predict the likelihood of sepsis. Next, we post-process these outcomes using statistical testing to improve prediction performance. We compare the results with benchmarks and draw insights.

5 - Detecting Clostridium Difficile Infection Clusters

Jeffrey Luo, Wolters Kluwer, Waltham, MA, United States

Clostridium difficile infection (CDI) is a well-known hospital acquired infection (HAI). It infects 500,000 patients per year resulting in 29,000 deaths and $4.8 billion in costs. CDI is extremely contagious and can be spread by touch or contact with contaminated objects or surfaces. It is therefore necessary to detect individual infections early and enact protocols to prevent the spread of CDI and what are known as infection clusters. In this presentation we expand on prior work to demonstrate how CDI cases frequently occur in clusters. We conclude that earlier detection and enactment of containment protocols could prevent these clusters from occurring and dramatically reduce CDI rates.

■ MC05

CC- Room 205

Data Analytics of Complex Data and its Applications

Sponsored: Data Mining

Sponsored Session

Chair: Elham Taghizadeh

1 - A Novel Data Adaptive Elastic Net Predictive Model for undersized High-Dimensional Data Sets

Shima Mohebbi, Assistant Professor, University of Oklahoma, Norman, OK, 73019, United States, mohebbi@ou.edu, Esra Pamukcu, Hamparsum Bozdogan

Many application domains (e.g. bioinformatics, image analysis, and medical data mining) are faced with a small sample and large dimensional data problems. We will focus on a novel Adaptive Elastic Net (AEN) modelling using a new covariance-regularization approach and introduce and score the Consistent and Misspecification Resistant Information Measure of Complexity criterion, and the Extended Consistent Akaike's Information Criterion with Fisher Information in AEN models for the first time. The proposed approach is applied to a real undersized benchmark dataset (Riboflavin) to predict the production rate of vitamin B2.

2 - Deep-Tier Supply Network Resilience Management

Elham Taghizadeh, Wayne State University, Detroit, MI, 48035, United States, elham.taghizadeh@wayne.edu, Ratna Babu Chinnam, Saravanan Venkatachalam

Globalization of industries has led to complex supply chains. Supply networks are vulnerable to several types of disruptions, both natural and operational. In our study, we propose methods to assess and manage the resilience of deep-tier supply networks of direct and upstream suppliers. Social network analysis techniques are combined with discrete-event simulation to improve accuracy of resilience assessment. This work is in collaboration with Ford Motor Company.

3- Automatic Extractive Summarization of Electronic Health Records

Azadeh Mobasher, Microsoft, Redmond, WA, 30067, United States, Amin Mobasher

Medical practitioners are required to process many electronic health records which mostly are published in healthcare/insurance systems to answer clinical queries and recommend prescriptions and advise patients. Due to the time-consuming nature of this practice, there is a huge need to build automated systems to find relevant medical data and extract useful information to improve physician and patient experience and reduce time to process. In this presentation, we talk about a multi-model deep learning binary classification network that is used to extract main content from medical documents, provide results and talk about how we use optimization methodologies to improve accuracy of our model.

■ MC06

CC- Room 209

Learning Through Intelligent Data Sampling

Sponsored: Data Mining

Sponsored Session

Chair: Xi Chen

1 - An Adaptive Streaming Data Sampling Strategy via Reinforcement Learning for Efficient Load Forecasting

Guangrui Xie, Virginia Polytechnic Institute and State University, Blacksburg, VA, 24061, United States, guanx92@vt.edu, Xi Chen, Yang Weng

This work aims at creating a "data-model-data" ecosystem for efficient and reliable load forecasting. The communication bandwidth constraints often imposed on data concentrators can lead to data deficiency for operational planning purposes in a dynamic, stochastic smart grid environment. In this work, we propose an adaptive data sampling scheme based on reinforcement learning to adjust streaming data sampling rates for improved load forecasting accuracy and efficiency. Numerical experiments show that the proposed method outperforms existing sampling schemes in terms of the overall predictive accuracy achieved.

2 - Data Farming and Data Mining: The Methods Behind the Metaphors

Susan M. Sanchez, Naval Postgraduate School, 1411 Cunningham Rd, GL 273, Monterey, CA, 93943, United States, ssanchez@nps.edu

The terms 'big data' and 'data mining' are often intertwined. but a key drawback to the data mining paradigm is that it relies on observational data and thus limits the types of insights that can be gained. With simulation and other computer models, the 'data farming' metaphor is more appropriate: it captures the notion of purposeful data generation. We will discuss some key methods behind the data farming and data mining metaphors, including some recent advances in large-scale design of experiments. We then demonstrate how data farming can yield 'better big data' by allowing analysts to establish causal relationships, and gain much broader insights from their models.

3 - A Bitcoin Blockchain Simulation Model

Ling Zhang, North Carolina State University, Raleigh, NC, United States, lzhang42@ncsu.edu, Yunan Liu, Hong Wan, Kejun Li

Blockchain has gained increasing attention both in industry and academia, and Bitcoin blockchain by many standards is the most successful application. We are interested in the interaction between miners and the Bitcoin network. We develop a simulation platform that aims to characterize key performance features and system dynamics of the Bitcoin blockchain network.

4 - Efficient Budget Allocation Strategies for Elementary Effects Method in Stochastic Simulation

Xi Chen, Virginia Polytechnic Institute and State University, Blacksburg, VA, 24601, United States, xchen6@vt.edu

We extend the Morris' elementary effects method (MM) for sensitivity analysis to the stochastic simulation setting. Given a fixed simulation budget to expend, the main objective is to provide efficient and accurate estimates of main and interaction (or nonlinear) effects coined by the standard MM for characterizing the importance of each factor, despite the impact of simulation errors. We develop efficient budget allocation strategies for implementing MM in this new context. Under each strategy, we derive the optimal budget partition and optimal budget allocation rules. Numerical results corroborate the practical effectiveness of the proposed budget allocation strategies.

■ MC07

CC- Room 210

Data Mining and Business Analytics

Sponsored: Data Mining

Sponsored Session

Chair: Michael Lash

Co: Chair: Shilpa Balan

1 - Interactions of Crowding, Patient Severity, and the Queuing Discipline at a Hospital Emergency Room

Lu Wang, University of Kansas, Ku Business School, Lawrence, KS, 66045, United States, lu.wang@ku.edu, Mazhar Arikan, Suman Mallik

Utilizing data from a large urban teaching hospital, we characterize how high severity patients might impact the length of stay(LOS) of low severity patients. We study how crowding, change in the queuing order, and severity affect the patient LOS.

2 - Spatiotemporal Modeling and Real-time Prediction of Origin-destination Traffic Demand

Xiaochen Xian, PhD, University of Florida, Gainesville, FL, 32611, United States, xxian@ufl.edu

Traffic demand prediction has been a crucial problem in transportation management. The prediction of traffic demand counts for origin-destination (OD) pairs has been a challenging problem due to the high variability and complicated spatiotemporal correlations. To tackle the challenges, we formulate and propose a multivariate Poisson log-normal model with specific parametrization tailored to the traffic problem, which captures the spatiotemporal correlations of the traffic demand across different routes and epochs, and automatically clusters the routes based on correlations. Simulations as well as a real application are performed to demonstrate its applicability and effectiveness.

3 - Diversity Preference-aware Link Recommendation in Online Social Network

Kexin Yin, University of Delaware, Newark, DE, 19711, United States, Xiao Fang

Friends recommended by existing link recommendation methods are generally homogeneous in terms of their backgrounds. In this presentation, based on the assumption that people may have different diversity preference on different dimensions of user background, a multi-dimensional diversity preference metric as well as a new link recommendation problem, namely diversity preference-aware link recommendation is formulated as a sum-of-ratio optimization problem and proofed to be NP-Hard. In order to solve the problem, an efficient heuristic solution method is further provided.

4 - Detecting ADHD Kids by Computer Performance Tests: Reverse Causality Machine Learner

Inbal Yahav, PhD, Tel Aviv University, Tel Aviv, Israel

We developed a Machine Learning detection model based on Continuous Performance Tests for ADHD in children. ADHD is one of the most common disorders worldwide. Alongside its commonality, there is no standard measure to detect ADHD, which leads to great over- and under- diagnosis. CPT was proposed as an objective measure of ADHD. Statistically, CPT-based detection is a reverse-causality problem that contradicts prevalent statistical theories. This mandates a careful hybrid theory- and data-driven detection model. Our ML detection model borrows from experiment design and minority detection, providing detection accuracy of 89%, placing CPT as a highly relevant ADHD detection tool in practice.

5 - The Development of a 28-Day Readmission Outcome-Trained Ensemble Learning Algorithm for Acute and Post-Acute Utilization Pattern Recognition

Jingjing Guan, City University of Hong Kong, jguan4@cityu.edu.hk, Eman Leung, Frank Y. Chen, Kwok-Kuen Mak

Here, we report the development of a novel data-based ensemble learning algorithm for recognizing patterns of patients' acute & post-acute service utilization with respect to their 28-day readmission outcomes. As ensemble learning permits the hybridization of classifiers of different levels to minimize the disadvantage of any single classifier, we included two high-level classifier systems to address the high noise-to-signal ratios associated with hospital length of stay & readmissions. Our algorithm yielded c-statistics of 81.7% & 75.5% for residential-care and community-dwelling samples respectively. The pattern of historical practices revealed service gaps & opportunities.

6 - Artificial Intelligence in Healthcare: Boon or Bane?

Shilpa Balan, California State University-Los Angeles, Los Angeles, CA, 90032, United States, sbalan@calstatela.edu

Artificial Intelligence (AI) is transforming everything connected to human life including healthcare. However, there is still a continuous debate of whether Artificial Intelligence is a boon or bane. While every technology has its advantages and disadvantages, the advantages most often prevail. While on the one hand, we seem to embrace technology changes such as smart home and smart healthcare, on the other hand, we are resistant of AI as it appears to attempt performing the human tasks. This presentation will examine the major areas in healthcare that could be significantly impacted by AI. For example, data mining and AI applications can be used to identify chronic diseases and high-risk patients.

■ MC08

CC- Room 211

AI ML Session

Emerging Topic: Artificial Intelligence & Machine Learning

Emerging Topic Session

Chair: Nathan Kallus, Cornell University, New York, NY, 10044, United States

Co-Chair: Hongseok Namkoong, Stanford University, Stanford, CA, 94305, United States

1 - Bounds on the Conditional and Average Treatment Effect in the Presence of Unobserved Confounders

Hongseok Namkoong, Stanford University, Stanford, CA, 94305, United States, Steve Yadlowsky, Sanjay Basu, John Duchi, Lu Tian

We study estimation of causal effects when the dependence of treatment assignments on unobserved confounding factors is bounded. We quantify bounds on the conditional average treatment effect under a bounded unobserved confounding model. We propose a semi-parametric framework to bound the average treatment effect (ATE) and derive corresponding confidence intervals for the bounds. This method extends the doubly robust estimator for the ATE, which assumes all confounding variables are observed. Our sensitivity analysis applies in higher dimensions than traditional sensitivity analyses allow. Optimality results show that our proposed bounds are tight in certain cases.

2 - Double Reinforcement Learning in Markov Decision Processes: Harnessing Memorylessness for Efficient and Robust Evaluation

Nathan Kallus, Cornell University, New York, NY, 10044, United States, kallus@cornell.edu, Masatoshi Uehara

Off-policy evaluation (OPE) in reinforcement learning allows one to evaluate decision policies without needing to conduct exploration, which is often costly or otherwise infeasible. We consider for the first time the semiparametric efficienc, y limits of OPE in Markov decision processes, where actions, rewards, and states are memoryless. We show existing estimators fail to be efficient in this setting. We develop a new estimator termed double reinforcement learning (DRL), which we show is both efficient and doubly robust. By harnessing memorylessness, DRL handily outperforms existing methods.

3 - Machine-learning Tests for Effects on Multiple Outcomes

Jann Spiess, Microsoft Research New England, Cambridge, MA, United States, jspiess@stanford.edu, Jens Ludwig, Sendhil Mullainathan

We present tools for applied researchers that re-purpose off-the-shelf methods from machine learning to create a “discovery engine” for data from randomized controlled trials (RCTs). The applied problem we seek to solve is that we invest vast resources into carrying out RCTs, but usually wind up exploring just a small subset of the hypotheses that the available data could be used to test. Our proposed solution combines the basic intuition of reverse regression, where the dependent variable of interest becomes treatment assignment itself, with methods from machine learning that use the data to flexibly identify whether there is any function of the outcomes that predicts treatment group status.

4 - Achieving Constant Regret in Restless Bandits and Weakly Coupled MDP

Xiangyu Zhang, Cornell University, Ithaca, NY, United States, xz556@cornell.edu, Peter Frazier

We study Weakly Coupled Markov Decision Processes (WCMDP), which generalize restless bandits with applications in revenue management, optimal learning and online ads. In a WCMDP we pull multiple arms per period. Each arm provides a reward, consumes resources, and is endowed with a stochastic state that changes even when not pulled. We study how regret scales with the number of arms K, holding fixed the fraction pulled per period. We develop a new policy, the Diffusion Index, whose regret is O(sqrt(K)) in general and o(1) under a non-degeneracy condition. This scaling with K is the best known.

■ MC09

CC- Room 212

Sequential Decision Making under Uncertainty

Sponsored: Artificial Intelligence

Sponsored Session

Chair: Junming Yin, University of Arizona, Tucson, AZ, 85721, United States

1 - Reviews, Biases and Six-sigma

Ningyuan Chen, University of Toronto, Clear Water Bay, Toronto, ON, Canada, Anran Li, Kalyan Talluri

Many empirical papers have documented a bias in the user ratings: an inherent self-selection in writing reviews. We give a precise characterization of the effect of the acquisition bias when consumers confound ex-ante innate preferences for a product or service with ex-post experience and service quality and do not separate the two. We develop a parsimonious choice model for consumer purchase decisions and show that it leads to an upward bias. Based on our theoretical characterization, we give two important practical applications for a service firm: (a) estimation of true process quality and its variability for the firm’s internal performance (b) effect on pricing and assortment decisions of the firm.

2 - Multinomial Logit Contextual Bandits

Min-hwan Oh, Columbia University, New York, NY, 10027, United States, m.oh@columbia.edu, Garud N. Iyengar

We consider a sequential assortment selection problem, in which a decision-maker decides which assortment to offer to users in order to maximize the cumulative reward. The feedback is an item chosen by a user which is given by the MNL choice model. The user’s preference for an item is a dynamic function of item features and user information, but the parameters of this function are unknown a priori. We refer to this problem as multinomial logit contextual bandit. We propose algorithms which simultaneously optimize assortment selections balancing between exploration and exploitation and learn user’s preference.

3 - Online Matching with Bayesian Rewards

Rui Sun, Massachusetts Institute of Technology, Cambridge, MA, 02139, United States, David Simchi-Levi, Xinshang Wang

We study in this paper an online ad allocation problem where a central platform needs to match ads of limited budgets to groups of customers that arrive in different time periods. The probability for a customer to click on an ad varies with the time period and the type of the ad. Moreover, the click probabilities are unknown, but drawn from known prior distributions. The goal of the platform is to maximize the total number of clicks without violating the budget constraints. We formulate the problem as a multi-armed bandit problem where each arm corresponds to a pair of ad and time period. We provide an algorithm based on assembling separate single-arm policies, and prove the algorithm’s performance guarantee.

■ MC10

CC- Room 213

High Success in Practical Social Applications

Sponsored: Analytics

Sponsored Session

Chair: Aaron Burciaga, Analytics2Go, Tysons, VA, 22102, United States

1 - Presenter

Aaron Burciaga, Analytics2Go, Tysons, VA, 22102, United States

2 - Presenter

Nick Wzientek, Independent Pet Partners, Littleton, CO, United States

■ MC11

CC- Room 214

Queueing Theory and Applications

Sponsored: Applied Probability

Sponsored Session

Chair: Johan van Leeuwaarden, Eindhoven University of Technology, Eindhoven, 5613 AD, Netherlands

1 - A Fluid Limit for an Overloaded Multiclass Many Server Queue with General Reneging Distribution

Amber L. Puha, California State University-San Marcos, Department of Mathematics, San Marcos, CA, 92096-0001, United States, Amy R. Ward

We study scheduling in a many server queue with general reneging distribution (G/G/N+G) and multiple customer classes. Motivated by the goal to formulate and analyze a fluid control problem, we specify a class of admissible control policies (rules for determining when to serve a given customer class), formulate a fluid model, and characterize the invariant states. Static priority policies do not capture the entire spectrum of invariant states, and so we introduce a set of control policies, called Random Buffer Selection (RBS) that do. We prove that a suitably rescaled state descriptor for the queue operating under specified RBS policy converges to the unique fluid model solution for that RBS policy.

2 - Discrete-time TASEP with Holdback

Alexander Stolyar, University of Illinois at Urbana-Champaign, Urbana, IL, 61801, United States, Vsevolod Shneer

We study a discrete-time interacting particle process, which can be called a totally asymmetric simple exclusion process with holdback (TASEP-H). The “holdback” refers to the property that the probability of a particle jumping forward to a vacant site depends on the presence of a particle immediately “behind” it. This is a basic model of a communication network with packets moving along a sequence of nodes, under a “standard” random access algorithm. We obtain results on “typical” invariant distributions of the process.

3 - Asymptotically Optimal Load Balancing Topologies

Debankur Mukherjee, Georgia Institute of Technology, Atlanta, GA, 02109, United States, debankur.mukherjee@isye.gatech.edu, Sem C. Borst, Amarjit Budhiraja, Johan S.H. van Leeuwaarden, Ruoyu Wu

We consider a system of N servers inter-connected by some graph topology GN. Tasks with unit-mean exponential service times arrive at various servers as independent Poisson processes of rate . Each incoming task is assigned to whichever server has the smallest queue length among the one where it appears and its neighbors in GN. This model has been extensively investigated via mean-field techniques in the case GN is a clique. For arbitrary graph, mean-field techniques breakdown, complicating the analysis. In this talk we investigate how much sparsity in the graph can be allowed maintaining the asymptotic behavior of a clique on a fluid and a diffusion scale.

4 - Information and Memory in Dynamic Resource Allocation

Kuang Xu, Stanford Graduate School of Business, Stanford, CA, 94305, United States, Yuan Zhong

We propose a general framework, dubbed Stochastic Processing under Imperfect Information (SPII), to study the impact of information constraints and memories on dynamic resource allocation. We quantify the degree to which information constraints reduce the size of the capacity region in general SPNs, and how such reduction depends on the amount of memories available to the encoding and allocation policies. Using a novel metric, capacity factor, our main theorem characterizes the reduction in capacity region for all non-degenerate channels, and across almost all combinations of memory sizes.

■ MC12

CC- Room 2A

Joint Session APS/Practice Curated: Markov Decision Process Applications

Sponsored: Applied Probability

Sponsored Session

Chair: Daniel F Silva, Auburn University, Auburn, AL, 36849, United States

1 - Optimal Routing in Loss Systems with Flexible Customers

Avnish Malde, Clemson University, Clemson, SC, 29634, United States, amalde@g.clemson.edu, Tugce Isik

We study a loss system with two classes of servers and a number of customer types. We assume that there is at least one class of flexible customers that can receive service from servers of either type. We formulate the problem as a Markov Decision Process with rewards that are dependent on the customer type. For small systems, we use our formulation to characterize the optimal policies. For larger systems, we prove that the optimal policies are structured, and of threshold type. Furthermore, for a large-scale system, the optimal threshold structure is explored numerically using stochastic dynamic programming. We also provide an application of our model in the context of electric vehicle charging.

2 - Optimal Control of Queueing Systems with Defects

Junqi Hu, Georgia Institute of Technology, Atlanta, GA, United States, jhu311@gatech.edu, Sigrun Andradottir, Hayriye Ayhan

We consider a Markovian system of tandem stations with finite buffers between the stations. Defects may be introduced during processing, resulting in the loss of the defective product. Servers are flexible but non-collaborative, and differ in terms of both their processing rates and defect probabilities at the stations. We identify the dynamic server assignment policy that maximizes the long-run average throughput of the system with two stations and two servers. For larger systems, we propose heuristic policies and provide numerical results showing our heuristic policies are near-optimal.

3 - Dynamic Routing and Vacation Control in a Two-class Parallel Queueing System

Mark E. Lewis, Cornell University, School of Ops Research & Information Engin., Ithaca, NY, 14853, United States, Pamela Badian-Pessot, Douglas Down

We consider the dynamic control of parallel queues. A decision-maker decides where to route arriving customers and when server vacations occur. Servers on vacation require a warm-up period before they are available. The structure of an optimal control is discerned with applications to server farms.

4 - Resource Allocation of Inspection Effort in Genetic Manufacturing Systems

Gregory T. Purdy, Assistant Professor, Auburn University, Auburn, AL, 36849, United States, greg.purdy@auburn.edu, Daniel F. Silva, Mohammad Maydanchi

Breakthroughs in molecular and synthetic biology through de novo gene synthesis are stimulating new pharmaceutical applications and advancing knowledge about the function of cells. This evolution in biological processing motivates the study of genetic manufacturing systems (GMS), which produce a final product with a genetic construct. Inspection and monitoring strategies are possible, but it is unclear if these techniques are cost efficient and value added. This talk investigates resource allocation strategies for GMS. A mathematical model is formulated to study the use of various inspection strategies in de novo gene synthesis, by adapting the multi-stage inspection allocation problem.

5 - Dynamic Same-day Order Delivery Planning Using Trucks and Drones

Daniel F. Silva, Auburn University, Auburn, AL, 36849, United States, silva@auburn.edu

We consider a parcel delivery operation that receives and dispatches orders throughout the day. The system has a single truck and must decide when to dispatch the truck, what orders to deliver, and the route. Additionally, there is a heavy-duty drone that can resupply the truck at pre-determined rendezvous points in the city. The system also decides when to dispatch the drone and what orders to include. We assume that order arrive following a Poisson process and model the problem as a Markov Decision Process. We will present the problem formulation, show sample results from small problem instances (with some additional assumptions), and discuss strategies for solving larger instances.

■ MC13

CC- Room 2B

APS/MSOM Uncert.: Modeling and Algorithmic Advances in Stochastic Optimization

Sponsored: Applied Probability

Sponsored Session

Chair: Karthyek Murthy, Singapore University of Technology and Design, Singapore, 487372, Singapore

1 - Bridging Bayesian and Minimax Mean Square Error Estimation via Wasserstein Distributionally Robust Optimization

Viet Anh Nguyen, Ecole Polytechnique Federale de Lausanne (EPFL), Lausanne, Switzerland, Soroosh Shafieezadeh-Abadeh, Daniel Kuhn, Peyman Mohajerin Esfahani

We bridge the Bayesian and the minimax mean square error estimators by leveraging tools from modern distributionally robust optimization. We show that the optimal estimator and the least favorable distribution form a Nash equilibrium for the Wasserstein ambiguity set and can be computed by solving a single tractable convex program. We further devise a Frank-Wolfe algorithm with a linear convergence rate to solve the convex program whose direction-searching subproblem can be solved in a quasi-closed form. Using these ingredients, we introduce an image denoiser and a robust Kalman filter which hedge against adversarial noise.

2 - Enhancing Optimality-feasibility Tradeoff for Data-driven Optimization under Uncertain Constraints

Huajie Qian, Columbia University, New York, NY, United States, Henry Lam

Optimization formulations to handle data-driven decision-making under uncertain constraints, such as robust optimization, often encounter a statistical trade-off between feasibility and optimality that potentially leads to over-conservative solutions. We show how we can exploit the intrinsic low dimensionality of the solution sets possibly output from these formulations to enhance this trade-off. We demonstrate the dimension-free performance of our strategy in obtaining solutions that are, in a sense, both feasible and asymptotically optimal among the considered class of formulations. We illustrate our approach for several common paradigms of data-driven optimization.

3 - Efficient Algorithms for Chance Constraint Optimization in Rare Event Regimes

Fan Zhang, Stanford University, 450 Serra Mall, Stanford, CA, 94305, United States, fzh@stanford.edu, Jose Blanchet, Bert Zwart, Fan Zhang

Chance constraint optimizations are known to be NP-hard, but it can be approximated by the scenario approach when the tolerance-violation is small. The number of sampled constraints in conventional scenario approach is inversely proportional to the tolerance-violation, which is computationally expensive when the chance constraint becomes increasingly rare. In this talk, we applied importance sampling to construct a rare event simulation estimator of which the number of sampled constraints is independent of the tolerance-violation.

4 - Efficient Estimation of Sensitivity of Tail Risk Measures with Applications in Risk Averse Stochastic Optimization

Karthyek Murthy, Singapore University of Technology and Design, Singapore, 487372, Singapore, karthyek@gmail.com, Anand Deo

Tail risk averse stochastic optimization is challenging in data-driven settings due to the lack of samples representing tail regions. We overcome this challenge by developing statistically sound approximations for the gradient of CVaR of the objective using extreme value based tail extrapolation methods. These approximations are a result of the limiting distributions we derive for suitably normalized versions of the objective and its gradient when conditioned on the objective being large. The utilization of extreme value based extrapolation of gradients to execute a first-order descent method is entirely novel in the setting considered and enjoys improved performance over plugin estimators.

■ MC14

CC- Room 302

Student Paper Competition 1

Sponsored: Manufacturing & Service Oper Mgmt

Sponsored Session

Chair: Feryal Erhun, University of Cambridge, Cambridge, CB2 1AG, United Kingdom

Co-Chair: Yi Xu, University of Maryland, DO & IT Department, Smith School of Business, College Park, MD, 20742, United States

Co-Chair: Antonio Moreno, Harvard Business School, Boston, MA, 02163, United States

1 - Matching in Online Marketplaces when Talent is Difficult to Discern

Jiding Zhang, The Wharton School, University of Pennsylvania, Philadelphia, PA, 19104, United States, Ken Moon, Karan Girotra, Elena Belavina

We study the problem of assigning workers to short-term jobs in online marketplaces, where workers aredistinguished in quality by attributes difficult to measure at scale, and can only be perceived through effortand cost. We use data on a major online freelancing platform to structurally estimate employers'preferences in hiring, including the uncertain information about workers' quality-relevant competencies,in a setting featuring large numbers of choices (freelancers) sorted into essentially unique considerationsets. We recommend how and when the platform should prioritize matching for compatible skills,matching for repeat relationships, and matching that encourages exploration.

2 - Multi-channel Delivery in Healthcare: The Impact of Telemedicine Centers in Southern India

Kraig Delana, London Business School, London, 97403, United Kingdom, Sarang Deo, Kamalini Ramdas, Ganesh Babu, Thulasiraj Ravilla

Telemedicine is increasingly used in rural communities across the developing world. However, the impactof telemedicine in these settings is not well understood. We analyze data from the Aravind Eye CareSystem in Southern India to examine the impact of opening telemedicine centers on access, treatments,and costs, at both the telemedicine center channel and the pre-existing hospital channel. We findevidence telemedicine centers improve access, particularly for patients with simple conditions, whichcontributes to an increase in the rates of glasses prescriptions. They also enable patients to substitutetelemedicine center visits for hospital visits leading to savings in patient costs.

3 - Inferring Consideration Sets from Sales Transaction Data

Mitrofanov Dmitry, NYU Stern School of Business, New York, NY, United States, Srikanth Jagabathula, Gustavo Vulcano

Overall, we study a methodology to identify consideration sets from sales transactions in a data-driven way. First, we address the problem of identifiability of consider-then-choose models from the data. Then, we suggest the framework to estimate these models and infer consideration sets. We apply the proposed methodology to the data obtained from a car-sharing platform and analyze the real-world settings where accounting for consideration sets can boost the predictive performance of the choice models. Our findings show that consider-then-choose models tend to be robust to the noise in the data and their relative importance in prediction tasks increases with the growing noise factor in the data.

■ MC15

CC- Room 303

Topics Related to Online Retailing

Sponsored: Manufacturing & Service Oper Mgmt

Sponsored Session

Chair: Yun Fong Lim, Singapore Management University, Singapore, 178899, Singapore

1 - Optimal Policies and Heuristics to Match Supply with Demand for Online Retailing

Fang Liu, Nanyang Technological University, Singapore, 639798, Singapore, liu_fang@ntu.edu.sg, Yun Fong Lim

Consider an online retailer selling multiple products to multiple zones over an infinite horizon. In each period, the retailer replenishes the products from a single supplier and stores them at multiple warehouses. After demand realization, the retailer determines the retrieval quantities. The retailer decides the order, storage and retrieval polices to maximize her expected total discounted profit. We completely characterize the optimal policies for a single demand zone. We propose heuristics to compute order and storage policies for multiple demand zones. A case study suggests that our heuristics generate at least a 15% profit improvement over the retailer's current practice.

2 - Product Description and Consumer Reviews in Omni-channel Retailing

Qiyuan Deng, Singapore Management University, Singapore, 545020, Singapore, qiyuan.deng.2015@pbs.smu.edu.sg

During the last decade, many brick-and-mortar retailers have initiated a dual-channel strategy supplementing their shops with online channels. More recently, retailers start to implement an omni-channel strategy, which aims to provide consumers the same shopping experience across channels. This paper studies how a retailer strategically provides product information in her offline and online channels. The two channels are operated either separately (dual-channel) or collectively (omni-channel). We consider two types of information: product description and consumer review. We develop a game-theoretical model to analyze the omni-channel strategy and the effect of consumer reviews.

3 - Managing Bucket Brigades on Discrete Stations with Stochastic Work Times: Learning is Not Always Good

Peng Wang, Singapore Management University, Singapore, 178899, Singapore, peng.wang.2016@pbs.smu.edu.sg

We study a J-station, 2-worker bucket brigade assembly line with stochastic work times. We derive the system's average throughput. If the work speeds depend only on the workers, we observe behaviors similar to that of the deterministic model. If the work speeds depend on the workers and the stations, we optimize a system consisting of a generalist and a specialist and uncover two factors determining the throughput. If the work speeds depend on the workers, the stations, and the jobs, the generalist and specialist may switch their roles as they learn. Furthermore, the throughput may drop as the workers learn.

4 - Technology Specifications and Production Timing in a Co-opetitive Supply Chain

Xin Fang, Singapore Management University, Singapore, 178899, Singapore, Baozhuang Niu, Kanglin Chen, Xiaohang Yue, Xin Wang

Motivated by Google's technology specifications on Android devices, we consider firms' decisions on production timing in a co-opetitive supply chain comprising a manufacturer and an original equipment manufacturer (OEM), where the manufacturer acts as the OEM's upstream contract manufacturer and downstream competitor. We consider the market acceptance uncertainty of key product designs. If a firm decides to implement ex-post production strategy (PS), it can delay the production until the market acceptance uncertainty of its product is resolved. Otherwise, ex-ante production strategy (AS) is implemented.

■ MC16

CC- Room 304

Advances in Process Flexibility

Sponsored: Manufacturing & Service Oper. Mgmt/Service Operations

Sponsored Session

Chair: Rene A. Caldentey, University of Chicago, Chicago, IL, 60637, United States

Co-Chair: Linwei Xin, University of Chicago, Chicago, IL, 60637, United States

Co-Chair: Yuan Zhong, University of Chicago / Booth School of Business, Chicago, IL, 60637, United States

1 - Optimal Capacity Rationing Policy with Individual Service Guarantees

Jiawei Zhang, Stern School of Business, New York, NY, 10012, United States, jzhang@stern.nyu.edu, Jiashuo Jiang, Shixin Wang

We study capacity allocation when customers require individual and possibly different service-levels. Our modeling framework generalizes and unifies many existing models in the literature. We show that, under a general class of randomized capacity rationing policies, our model can be formulated as a minimax stochastic program. An immediate consequence of this formulation is the application of existing first-order optimization algorithms to numerically compute capacity levels. The formulation also allows us to derive an intuitive and optimal rationing policy for the second stage capacity allocation problem. In addition, we derive conditions under which an index policy is optimal.

2 - Assessing the Cost of Flexibility in Demand Fulfillment: An Empirical Study

Yifan Feng, University of Chicago, Chicago, IL, United States, yifan.feng@chicagobooth.edu, Rene A. Caldentey, Linwei Xin, Dennis Zhang

Our study is based on a dataset from a major logistics platform for e-commerce business in China. We quantify the impact of fulfillment flexibility on delivery speeds.

3 - Capacity Allocation and Online Fulfillment under Asymmetric Demand

Hailun Zhang, The Chinese University of Hong Kong, Shenzhen, 5569, Clear Water Bay, Shen Zhen, China, hzhangaq@connect.ust.hk

We study online demand fulfillment with limited flexibility and highly asymmetric demand nodes. Xu et al.(2017) show that, under a load-based demand fulfillment rule, a positive Generalized Chaining Gap (GCG) is both necessary and sufficient to achieve bounded performance and the performance bound as a proxy of the performance measure (i.e., the expected number of lost sales) suggests that a high GCG leads to good performance. Since the GCG of a given network with highly asymmetric demand notes can be arbitrary low as the level of asymmetry increases, we investigate in this paper whether bounded performance can be achieved as GCG vanishes and provide insight into ways to achieve bounded performance.

4 - On the Learning Benefits of Resource Flexibility

Mihalis Markakis, IESE Business School, Avenida Pearson, Barcelona, 08034, Spain, Jiri Chod, Nikolaos Trichakis

Resource flexibility is known to provide firms facing demand uncertainty with such benefits as risk pooling, revenue-maximization optionality, and operational hedging. In this article we uncover a heretofore unknown benefit: we establish that resource flexibility mitigates censoring of sales data, and thereby facilitates learning the true demand under a variety of practical settings and demand distributions. Further, we quantify these learning benefits of flexibility and find them to be of the same order of magnitude as the extensively studied risk pooling benefits of flexibility.

■ MC17

CC- Room 305

High-dimensional MDP in OM

Sponsored: Manufacturing & Service Oper. Mgmt/Service Operations

Sponsored Session

Chair: David Goldberg, Cornell University, Ithaca, NY, 14850, United States

1 - Near Optimal Solutions for Assemble-to-Order Systems

Yehua Wei, Duke University, Durham, NC, 02467-3809, United States, Levi DeValve, Sasa Pekec

We study the classical assemble-to-order (ATO) problems from Operations Management. We present LP rounding algorithms that achieve both asymptotic optimality as demand grows large, and a 1.8 approximation factor for any one-period ATO problem instance. We also demonstrate that our one-period LP rounding results can be extended to analyze dynamic ATO problems. Specifically, we use our rounding scheme to develop an asymptotically optimal integral policy for dynamic ATO problems with backlogging and identical component lead-times.

2 - Information and Memory in Dynamic Resource Allocation

Yuan Zhong, Booth School of Business, University of Chicago, Chicago, IL, United States, Yuan.Zhong@chicagobooth.edu, Kuang Xu

We propose a general framework to study the impact of information constraints and memories on dynamic resource allocation. Information constraints are modeled as a channel, where a sender/encoder co-located with the buffers sends signals across the channel to the decision maker, who receives a noisy message. Memories are available to both the sender and the receiver (decision maker). We prove in substantial generality that (a) noisy information always reduces capacity; (b) more receiver memory always improves capacity; and (c) more sender memory has little to no effect on memory. All of our positive (achievability) results are established through constructive, implementable policies.

3 - Dynamic Pricing of Relocating Resources in Large Networks

Chen Chen, Duke University, Durham, NC, United States, cc459@duke.edu, Santiago Balseiro, David Brown

We study dynamic pricing of resources distributed over a network of locations. Customers with private willingness-to-pay sequentially request to relocate one resource, and a revenue-maximizing service provider sets a price for each request. We focus on networks with a hub-and-spoke structure, and develop a dynamic pricing policy based on a Lagrangian relaxation. We show the policy loses no more than $O(\sqrt{(\ln n/n)})$ in performance when the number of spokes n and the number of resources grow at the same rate. Finally, we extend the approach and analysis to more general networks with multiple hubs and spoke-to-spoke connections. No static policy is asymptotically optimal in the regime we consider.

4 - Beating the Curse of Dimensionality in Options Pricing and Optimal Stopping

Yilun Chen, Cornell ORIE, 292 Rhodes Hall, Ithaca, NY, 14853, United States, yc2436@cornell.edu, David Goldberg

The fundamental problems of pricing high-dimensional options and optimal stopping are generally believed to be intractable, with modern ADP, duality, and simulation approaches either scaling poorly, requiring knowledge of basis functions, or having limited guarantees. We show that this general belief is incorrect, by developing the first algorithm which allows one to elegantly trade-off between accuracy and runtime through a parameter epsilon controlling the performance guarantee (analogous to a PTAS), with computational and sample complexity both polynomial in T (effectively independent of the dimension) for any fixed epsilon, in contrast to past methods which scale exponentially.

■ MC18

CC- Room 306

Joint Session MSOM/SC/Practice Curated: Empirical Service Operations

Sponsored: Manufacturing & Service Oper. Mgmt/Supply Chain

Sponsored Session

Chair: Ruomeng Cui, Emory University, Decatur, GA, 30033, United States

1 - Disruptions, Resilience and Performance of Emerging Market Entrepreneurs: Evidence from Uganda

Amrita Kundu, London Business School, London, NW1 4SA, United Kingdom, akundu@london.edu, Kamalini Ramdas, Stephen Anderson

We examine the effect of firm-specific business disruptions (both managerial and operational) on the performance of small firms in emerging markets and the effectiveness of appropriate resilience strategies in buffering against these disruptions, using a hand-built panel dataset on 646 small firms over four time periods in Kampala, Uganda.

2 - Product Management under Competitive Dynamics

Xabier Barriola, IESE Business School, Av. Barcelona, 08034, Spain, xbarriola@iese.edu, Jose Azar

In this paper we test the effects of competition on product assortment, on the number of new products released, and on the time between the release of new products. Using the merger between SABMiller and Molson Coors as an instrument to predict future market structure, we conclude that competition makes firms offer larger levels of product assortment. Moreover, we show that there is a negative relationship between the number of new products and market concentration. Finally, we are able to show that there is a positive relationship between release times and market concentration. Our findings confirm the notion that more competition creates an arms race, where firms decide to release new products faster.

3 - Challenges of Online Retailing in Emerging Markets

Antonio Moreno, Harvard Business School, Morgan Hall 494, Boston, MA, 02163, United States

This talk focuses on some of the challenges of online retailing in emerging markets, such as the use of cash on delivery.

4 - Worker Turnover in the Global Supply Chain

Ken Moon, The Wharton School, Wharton School, Philadelphia, PA, 19104, United States, kenmoon@wharton.upenn.edu

We study worker turnover and production data from within a global supply chain involving over 700 suppliers to produce billions USD in consumer electronic goods quarterly. Within the supply network, worker turnover rates at some of the component suppliers approach 400-500% annually. Our empirical and prescriptive study examines how yield volatility caused by disruptive worker turnover can generate supply-side bullwhip effects, and how these effects trade off with prescriptions based on prior literature prescribing that risk mitigations (such as safety stocks) be installed further upstream within the responsive supply chain.

5 - Sooner or Later? Learning from Delivery Speed Information

Ruomeng Cui, Emory University, Decatur, GA, 30033, United States, ruomeng.cui@emory.edu, Tianshu Sun

Online retailers who sell physical products need to inform customers how fast an order can be delivered. On one hand, an aggressive (faster) delivery estimate could meet more demand and thus may increase current sales. On the other hand, however, it may also raise the likelihood of customers experiencing a loss in time due to a longer than expected wait, which might hurt future sales. Collaborating with an online store selling custom products, we exploit its shipping rule changes intending to identify the effect of delivery information. We leverage the exogenous policy change and use a difference-in-difference approach to examine whether and how consumers respond to the delivery information.

■ MC19

CC- Room 307

Innovative Operations Models

Sponsored: Manufacturing & Service Oper. Mgmt/Supply Chain

Sponsored Session

Chair: Fuqiang Zhang, Washington University in St. Louis, St. Louis, MO, 63130, United States

Co-Chair: Tianjun Feng, Fudan University, Shanghai, 200433, China

1 - Wishful-thinking Investors on Peer-to-peer Lending Platforms: Implications for Supply Chain Financing

Xin Fang, Singapore Management University, 50 Stamford Road, #05-01, Singapore, 178899, Singapore, Guangxin Gao, Yun Fong Lim

In recent years, online peer-to-peer (P2P) lending platforms grow rapidly. Different from traditional bank financing, a borrower on a P2P platform seeks fund from many investors and the investors in turn bear the borrower's default risk. However, some investors are wishful thinking on the platform, who ignore the default risk and only focus on investment returns. We study the impacts of such wishful-thinking investors on supply chain financing. We develop a game-theoretical model involving a capital-constrained retailer, a P2P platform and a group of heterogeneous investors, who can be rational or wishful-thinking.

2 - Peer-to-peer Sharing Platforms with Quality Differentiation: Manufacturer's Strategic Decision under Sharing Economy

Huiqi Guan, Fudan University, Shanghai, 200433, China, guanhuiqi@fudan.edu.cn, Xin Geng, Haresh B. Gurnani

We formulate a multi-stage game-theoretic model to analyze the manufacturer's strategic move of building an exclusive product sharing platform to respond to the competition from the emerging peer-to-peer product sharing platforms in the downstream market. Our results indicate that a high-quality manufacturer can benefit from building a peer-to-peer sharing platform.

3 - Incentivizing Farmer Adoption of Agri-Technology Products

Xiao Tan, Washington University in St. Louis, St. Louis, MO, United States, xtan@wustl.edu, Duo Shi, Fuqiang Zhang

With development of agriculture technology, new agri-technology products like UAV help farmers with seeding and fertilizing. However, it is of high risk and uncertainty to use these products. We characterize heterogeneous farmers' behaviors in equilibrium when they engage in Cournot competition. Also we study the firm's optimal effort and price regarding farmers' behaviors. Government may able to subsidize farmers or the firm. Our analysis will show which player should be subsidized under certain conditions.

4 - Real Estate Investments and House Sharing: Impacts and Implications on Local Housing Markets

Jiali Huang, University of Minnesota, Minneapolis, MN, 55414, United States, Saif Benjaafar, Ankur Mani, Shihong Xiao

It is commonly believed that the existence of home investors may raise housing price and thus increase the living cost of local residents. This rule of thumb may not be valid when there is a peer-to-peer home sharing market for home owners to rent their house when they do not use them. We propose a game-theoretic model to investigate the interactions of landlords, home developers, local residents, home investors, and home-sharing platform. We show the existence and uniqueness of the equilibrium, and examine monotone comparative statics of rental price, home purchasing price, the welfare of local residents, and social welfare.

■ MC20

CC- Room 308

Assessment for OR/MS/Analytics Education

Sponsored: Education

Sponsored Session

Chair: Susan Wright Palocsay, James Madison University, Harrisonburg, VA, 22807, United States

1 - Innovation and Assessment of Advising Models in an undergraduate Industrial Engineering Program

Jill Hardin Wilson, Asst. Dept. Chair for Undergraduate Studies, Northwestern University, Industrial Engineering & Mgmt Sciences, 2140 Sheridan Road, Evanston, IL, 60208, United States, Marita Labedz Poll

In the McCormick School of Engineering at Northwestern University, all undergraduate students are required to meet quarterly with an academic advisor. These advisors have traditionally been full time faculty. We pilot and assess a new model for advising in Industrial Engineering that combines a professional academic advisor with a faculty "guIdE". In its first two years this model has demonstrated equivalent student satisfaction and continued student-faculty engagement, while releasing full-time faculty from the high number of contact hours previously required for curriculum advising.

2 - Industry Advisory Board Input for Data Science and Industrial and Applied Mathematics Curriculum Development

David W. Jacobson, Associate Professor, Metropolitan State University, 5703 Clearwater Rd NW, St. Paul, MN, 55901-4114, United States, david.jacobson@metrostate.edu, Rikki Wagstrom

Many universities have developed or are developing data science programs. Others have redesigned their traditional Applied Mathematics degrees. In this presentation, we will discuss recommendations and input that we have received from our Industry Advisory Board which is made up of representatives from a wide range of business enterprises. We will cover their suggestions and how several have been implemented in our Data Science and Industrial and Applied Mathematics curricula.

3 - Assessment of Memorandum Writing About Analytical Work

Julie Ann Stuart Williams, Professor, University of West Florida, 11000 University Parkway, Building 76A Room 328, Pensacola, FL, 32514-5752, United States, jawilliams@uwf.edu

A contextualized problem that integrates mathematical modeling and professional writing provides an assessment approach for students to demonstrate not only modeling formulation and solution technique but also management interpretation and writing. The assessment rubric includes management interpretation requirements for the content in terms of the decisions, objective, constraints, solution, recommendation, and impact as well as writing requirements for grammar, punctuation, capitalization, and spelling. A detailed example illustrates the assessment approach. Assessment results over multiple years are summarized and pedagogical implications are discussed.

4 - A Spreadsheet Tool for Analyzing Assessment Test Data

Luis J. Novoa, James Madison University, 421 Bluestone Dr., Zane Showker Hall, Harrisonburg, VA, 22807, United States, novoadlj@jmu.edu, Scott Stevens, Susan Wright Palocsay

We have developed an Excel-based tool to support analysis and reporting of data from assessment tests. It creates graphical and tabular summaries of test results at the question item, course topic, instructor, and semester levels. We will demonstrate its use for automation of question grouping, statistical analyses, and report generation.

5 - Experiences with Assessment Testing in an undergraduate MS Course

Scott Stevens, Professor, James Madison University, Harrisonburg, VA, 22807, United States, stevensp@jmu.edu, Susan Wright Palocsay, Luis J. Novoa

We will describe our experiences in developing and implementing course-embedded test questions for assurance of learning in a required MS course. Example learning objectives, test items, and assessment results will be presented. We will also address how we have addressed challenges with "closing the loop" for continuous improvement.

■ MC21

CC- Room 309

Blockchain and Cryptocurrencies

Sponsored: Manufacturing & Service Oper. Mgmt/iFORM

Sponsored Session

Chair: Gerry Tsoukalas

1 - Blockchain-driven Deep-tier Supply Chain Finance

Yunzhe Qiu, Washington University in St. Louis, , St. Louis, MO, 63130, United States, qiuyunzhe@wustl.edu, Lingxiu Dong, Fasheng Xu

We study the financing problem in a multitier supply chain with one downstream manufacturer (buyer), one tier-1 supplier (intermediary), and two tier-2 suppliers who are in need of working capital to survive business disruptions (e.g., production line breakdowns, delayed customer payments). With such three-tier supply chain as the backdrop, the downstream manufacturer has limited visibility of financial status (i.e., cash position) of the tier-2 suppliers. However, with the blockchain technology, such deep-tier visibility issue can be can resolved. We further provide a sufficient condition under which the blockchain-driven visibility could lead to a "win-win-win" situation.

2 - Cryptocurrency Design

Nick Arnosti, Columbia Business School, New York, NY, 10027, United States, Ciamac Cyrus Moallemi

Cryptocurrencies must compensate miners for validating transactions and protecting the network against attacks. This compensation can come in the form of block rewards or transaction fees. Existing cryptocurrencies compensate miners in different ways. For example, block rewards may be decreasing or constant over time, and fees may be voluntary or mandatory. We formulate a model in which block rewards and transaction fees determine the security of the network, as well as its usefulness to users. We consider the social planner’s problem of maximizing welfare subject to security constraints, and discuss the effect of block rewards and transaction fees on the value of the currency.

3 - Inventory, Speculators and Initial Coin Offerings

Rowena J. Gan, Wharton School of Business, University of Pennsylvania, Philadelphia, PA, United States, ganj@wharton.upenn.edu, Gerry Tsoukalas, Serguei Netessine

Initial Coin Offerings (ICOs) are an emerging form of fundraising for Blockchain-based startups. We propose a simple model of matching supply with demand with ICOs by companies involved in production of physical products. We examine how ICOs should be designed-including optimal token floating and pricing-in the presence of demand uncertainty, make predictions on ICO failure, and discuss the implications on firm operational decisions and profits. We show that ICOs are best suited for higher-margin products, and lead to underproduction and lower-than-optimal profits versus first best. However, ICOs result in lower profit variance, rendering firm profits less sensitive to demand uncertainty.

4 - Token Weighted Crowdsourcing

Gerry Tsoukalas, Wharton School of Business, Philadelphia, PA, 19104, United States, gtsouk@wharton.upenn.edu

Blockchain-based systems are increasingly using token weighted voting to crowdsource information from their users for a wide range of applications, including content curation, and on-chain governance. We examine the effectiveness of such decentralized systems at harnessing the ``wisdom” and ``effort” of the crowd.

■ MC22

CC- Room 310

Consumer Returns in Retailing

Sponsored: Manufacturing & Service Oper. Mgmt/Sustainable Operations

Sponsored Session

Chair: Necati Ertekin, University of Minnesota, Minneapolis, MN, United States

1 - On Product Customization and Returns

Paolo Letizia, University of Tennessee, 916 Volunteer Boulevard, Knoxville, TN, 37996, United States, pletizia@utk.edu, Gokce Esenduran, Anton Ovchinnikov

Nowadays, consumers are increasingly searching for products that closely match their preferences, but also feel entitled to return the purchased products, whether standard or customized, in case the products do not match their expectations. The firms’ response to these two trends is far from being unique. Even in the same industry, some firms provide ways to customize, while others sell only standard products; likewise, some embrace liberal return policies even for customized products, while others allow returns of only standard products. Given these, at times, opposing practices, this article analyses firms’ decisions about product customization and returns.

2 - Using Transactions Data to Improve Consumer Returns Forecasting

Guangzhi Shang, Florida State University, Department of Marketing, College of Business, Tallahassee, FL, 32306, United States, Erin Cassandra McKie, Mark Ferguson, Michael Galbreth

Although an accurate returns forecast is preliminary for many decision support tools for managing returns, the development methods in this area received relatively little attention. We propose a new approach and benchmark its performance against a number of existing methods using two real world datasets.

3 - Consumer Bracketing of Online Purchases to Manage Size Uncertainty – Should Retailers Be Worried?

Aditya Balaram, University of South Carolina, Columbia, SC, 29208, United States, aditya.balaram@grad.moore.sc.edu, Olga Perdikaki, Michael Galbreth

Bracketing is the practice of ordering multiple sizes of a product and returning all that do not fit. Consumers adopt this practice to resolve uncertainty surrounding size. Bracketing results in retailers having to deal with a larger mass of returns, which is a situation they would like to avoid. We build a stylized model to show that online retailers can leverage this seemingly deleterious consumer practice to improve profit by pricing appropriately.

4 - Mitigating Quality Related Consumer Returns: The Role of Store Labor

Necati Ertekin, University of Minnesota, Department of OM&IS, Leavey School of Business, Minneapolis, MN, 95053, United States, Xiaojing Dong

The implication of product quality-consumer returns relationship may be impractical due to not only the challenges to improve perceived product quality but also the lack of association between low quality and certain products. We propose an alternative quality-returns relationship that is both theoretically grounded and practically actionable.

■ MC23

CC- Room 3A

Theoretical Issues in Decision Analysis

Sponsored: Decision Analysis

Sponsored Session

Chair: Ying He

1 - Everything in Moderation: Foundations and Applications of the Satiation Model

Manel Baucells, University of Virginia, Darden School of Business, 100 Darden Boulevard, Charlottesville, VA, 22903, United States, mbaucells@gmail.com, Lin Zhao

Satiation is an essential factor influencing preferences and the design of experiential services. We provide behavioral foundations for an additive utility functional, together with the existence of a state that influences instant utility. We provide a novel proof of concept on how to elicit the preference parameters. On the implementation side, we develop a mixed integer formulation to solve the optimal design of experiential services. Our last result is a preferential equivalence between event utility and recall utility.

2 - A Two Stage Evaluation Model for Decision Making under Ambiguity

Ying He, University of Southern Denmark, Campusvej 55, Odense, M, 5230, Denmark, yinghe@sam.sdu.dk

In this paper, a two-stage evaluation (TSE) model for decision making under ambiguity. In this model, two different types of uncertainty are evaluated in different stages. In the first stage, DM evaluates more uncertain consequences by applying local SEU models, which are then embedded into the second stage evaluation based on a SEU. When evaluating a risky act, the TSE model reduces to the Savage’s SEU with one stage. When evaluating an ambiguous act, the local SEU with a different uncertainty aversion gives the TSE model some flexibility in describing preference. This TSE generates the Uncertain Expected Utility and overlaps with the Smooth Ambiguity Model in modeling preferences.

3 - What Drives the Magnitude Effect?

Alessandra Cillo, PhD., Bocconi University, Milan, Italy, Manel Baucells

The magnitude effect is one of the most robust phenomena in observed time preferences. Often, one considers the prospect of a cash flow, rather than a single payout. In this case, it is unclear whether the magnitude effect is driven by the sum of cash flows, or the highest cash flow, or the first, or the last, or the lowest. In this paper, we create an orthogonal design to shed light into this question. We discuss the implications of our results for how to design more appealing consumer credit offerings.

4 - Information Density in Sensitivity Analysis and Optimization

Emanuele Borgonovo, Bocconi University, Milano, 20136, Italy, Emanuele.Borgonovo@unibocconi.it, Gordon B. Hazen, Victor Jose, Elmar Plischke

In this work, we discuss the notion of information density and how it relates to sensitivity analysis and optimization.

5 - Disentangling Technology Management from Financial Portfolios

Ekundayo Shittu, George Washington University, Washington, DC, 20052, United States, eshittu@gwu.edu, Zoe Szajnfarber

It has been demonstrated in literature that the notion of technology portfolio management shares characteristics with equity portfolio investments in finance. For example, the efficient frontier always traces a path of optimal asset combination for either an equity or a technology portfolio. However, we find that this is only true based on very strong assumptions that equate the nature of technologies with equities. In this paper, we provide three attributes that underscore how this age-long assumption is sub-optimal.

■ MC24

CC- Room 3B

Building MCDM/A Models: Practical and Methodological Issues

Sponsored: Multiple Criteria Decision Making

Sponsored Session

Chair: Caroline Miranda Mota, Universidade Federal de Pernambuco, Recife, Brazil

Co-Chair: Danielle Morais, Universidade Federal de Pernambuco, Recife - PE, 52020-212, Brazil

1 - A Spatial Multiple Criteria Decision Model for Vulnerability Analysis

Caroline Miranda Mota, Universidade Federal de Pernambuco, R. Academico Helio Ramos S/N, Depto Eng de Producao-CTG CDU Recife - PE, Recife, Brazil, Ciro Figueiredo

This study used a spatial MCDA approach, based on Dominance-based rough set approach and preference to evaluate the vulnerability of places at crime level. The approach explored aggregation of those individual results for obtaining a final output recommendation. The preferences of each decision maker is assessed in an interactive and incremental way. The preferences were assessed in an interactive way, starting from a small subset of holistic evaluations. The approach was proposed to evaluate places according to its vulnerability to crime occurrence and suggesting where limited resources should be allocated.

2 - Classification Model for Bid / No Bid Decision

Maria Creuza Borges de Araújo, PhD, Universidade Federal de Campina Grande, Sumé, Brazil, mariacreuzaborges@yahoo.com.br, Luciana Hazin Alencar, Caroline Miranda Mota

The bidding decisions are strategic for project-oriented companies. Therefore, we build a classification multiple-criteria model for supporting the decision between bid or not, considering the attractiveness of the projects. The model's main contributions are: (1) the better use of decision maker preference's information for defining project attractiveness levels, and (2) making use of the result of the model as an input for the markup estimation. Moreover, the classification can support the DM to prioritize the projects to bid and model is appropriate in cases where past data are not available.

3 - Selection of Voting Procedure Applied on Participatory Budgeting

Jose Leão Silva FIlho, PhD, Universidade Federal de Pernambuco,, Caruaru, Brazil, zeleao@gmail.com, Danielle Morais

The voting literature presents some procedures to aid different decisions. Each procedure has its own positive and negative characteristics. The choice of a voting procedure (VP) to aggregate the preferences of a group can be a challenge when the decision maker desires a democratic and effective VP. The Participatory Budgeting (PB) scenario in Brazil is an example of these difficulties of choosing a VP. Then, this study presents a multicriteria model to choose the most appropriate VP for a PB considering the characteristics of the problem, the city analyzed and the properties of VP.

4 - A Dempster – Shafer Approach for Multiple Criteria Hierarchy Process

Lucimario Gois Silva, Universidade Federal de Pernambuco,, Caruaru, 50740-550, Brazil, lucio_gois@hotmail.com

In many situations involving multicriteria decision problems, the analysis of the criteria may assume a hierarchical structure of disposition among the criteria. In this case, there is what is called Multiple Criteria Hierarchy Process (MCHP) in the literature. Thus, this new structure for analyzing the criteria requires a new way of thinking about how the criteria relate mainly regarding the definition of weights (relative importance among the criteria). Following this rationale, a new form of weight elicitation which combines the MCHP with the Dempster-Shafer theory is presented, taking into account the possibility of vagueness and inconsistency of the decision-maker.

5 - Building a Multicriteria Decision Making Model for Prioritizing Brazilian Federal Police Activities

Carla Patricia Cunha, Master, Universidade Federal de Pernambuco - Policia Federal, Recife, Brazil, cunhacarla1976@gmail.com, Caroline Miranda Mota, Adiel Teixeira De Almeida, Eduarda Frej

This work intends to build a MCDM/A model to support the decision-making process for prioritizing operational activities of the Brazilian Federal Police. The model considers the organizational values under an investigative aspect and the duties of Brazilian Federal Police. In this context, this work demonstrates the significant decision support that may come from the application of the flexible and interactive tradeoff method (FITradeoff) to assess the values and objectives of the Federal Police.

■ MC25

CC- Room 401

Managing Human and Material Resources in Humanitarian Supply Chains

Emerging Topic: Humanitarian and NotforProfit Operations

Emerging Topic Session

Chair: Lauren Berrings Davis, North Carolina A&T State University, Greensboro, NC, 27411, United States

1 - Optimizing Spontaneous Volunteer Assignment in Response to Disaster Relief Efforts

Hussain Abualkhair, North Carolina A&T State University, Greensboro, NC, 27407, United States, hfabualk@aggies.ncat.edu, Lauren Berrings Davis, Emmett J. Lodree

Disaster relief centers serve as a primary hub for receiving and distributing relief items. Not only do they face uncertainty in the number of donors dropping off items and beneficiaries picking up items, they also deal with a large influx of spontaneous volunteers. Managing allocation of spontaneous volunteers is challenging due to uncertain arrival times and their participation time. This research presents an infinite horizon discrete time discrete state Markov Decision process model that determines the optimal volunteer assignment policy given the aforementioned uncertainty. The goal is to maximize the number of donors and beneficiaries served and minimize the number of idle volunteers.

2 - Modeling the Role of Equity by Food Group in Effective and Efficient Distribution of Donated Food

Md Hafizul Islam, North Carolina State University, Raleigh, NC, 27695, United States, mislam5@ncsu.edu, Julie Simmons Ivy

Food banks feed more than 41 million people in the United States suffering from hunger every year. They collect in-kind donations to serve as many of these people as possible in an efficient and equitable manner. A mixed integer programming model is developed to identify efficient and effective policies to collect donations of various food groups and allocate them to different demand zones maintaining equity at the food group level. A numerical study using data from the Food Bank of Central and Eastern North Carolina is performed to explore the impact of the variable capacity for processing, storing, and distributing different types of food on the efficient, effective and equitable allocation policy.

3 - Nested Markov Decision Process Model for Equitable and Effective Supply Distribution

Sefakor Fianu, North Carolina A&T State University, Greensboro, NC, 97229, United States, sfianu@aggies.ncat.edu, Lauren Davis

Food banks have evolved from small backyard operations into complex network organizations as a result of increase in demand for their services. However, most of their supplies primarily come from donations which create a major challenge in their supply chain. Distribution decisions made by food banks usually include: how to transfer supplies from one branch to another and how to effectively distribute these supplies to partner agencies. These decisions are dependent on one another and require an integrated decision-making process. The problem is formulated as a Nested Markov Decision Process with objectives of finding optimal distribution policies that minimize unsatisfied demand and waste.

4 - Determining Optimal Fuel Delivery Strategies under Uncertainty

Dominiqueca Edwards, North Carolina A&T, Greensboro, NC, United States, dredward@aggies.ncat.edu, Lauren Berrings Davis, Pitu B. Mirchandani, Sierra Marshall

In preparation for a hurricane, potential individuals affected by the hurricane often are required to evacuate. Evacuations can cause high increases in the demand for gasoline fuel needed for transportation. Since the incoming fuel is imported by vessels, they often have to divert from the intended destination port due to the path of a hurricane. The purpose of this research is to determine a real time port diversion strategy for incoming fuel vessels given the forecast of an approaching hurricane. We develop a heuristic scheduling algorithm that finds the optimal diversion strategy that minimizes the unmet demand of gasoline fuel in each county.

■ MC26

CC- Room 4C-1

IBM Best Student Paper Award III

Sponsored: Service Science

Sponsored Session

Chair: Aly Megahed, IBM Research - Almaden, San Jose, CA, 95123, United States

Co-Chair: Paul R Messinger, University of Alberta, Edmonton, AB, T6G 2R6, Canada

1 - IBM Best Student Paper Award

Paul R. Messinger, University of Alberta, Faculty of Business, Edmonton, AB, T6G 2R6, Canada, paul.messinger@ualberta.ca

From a highly competitive pool of submissions, a set of finalists has been selected by a panel of Service Science Section Leaders. In this session, these finalists will present their research findings to a panel of judges and a general audience. This award recognizes excellence among the section's student members and brings prestige to the Service Science Section as well as to the recipients honored.

■ MC27

CC- Room 4C-2

Data Analytics in Service Operations

Sponsored: Service Science

Sponsored Session

Chair: Yuqian Xu, University of Illinois at Urbana-Champaign, Champaign, IL, 61820, United States

1 - On Gradient Descent Ascent for Nonconvex-concave Minimax Problems

Tianyi Lin, University of California, Berkeley, 407, Berkeley, CA, 94706, United States, darren_lin@berkeley.edu, Chi Jin, Michael Jordan

We consider the nonconvex-concave minimax problems. The standard algorithm for solving this problem is the celebrated gradient descent ascent (GDA), which has been a major success in machine learning, control theory and economics. Despite the thorough theory in convex-concave setting, GDA can converge to limit cycles or even diverge in general setting. In this paper, we present a nonasymptotic analysis of GDA for solving the nonconvex-concave minimax problems. To the best our knowledge, our work is the first to provide the theoretical guarantee for GDA in this setting, shedding the light to its great practical performance in many real applications.

2 - Unnesting the Fixed Point in the Estimation of Dynamic Programs with General Utility Function

Robert Louis Bray, Kellogg School of Management, Northwestern University, 830 Hinman Ave., 2s, Evanston, IL, 60202, United States, r-bray@kellogg.northwestern.edu

A conditional choice probability (CCP) estimator of a dynamic empirical model solves both a dynamic programming problem and a maximum likelihood problem. The estimator can dispatch the former problem before tackling the latter when the utility function is linearly parameterized; otherwise it must nest the former within the latter. This ``nested fixed point" bogs down the estimator. I develop a method to disentangle the two problems under any utility function.

3 - Building Recommendations Through Various Algorithms: Online Grocery Market

Christine Nguyen, Point B, Seattle, WA, United States, Arrido Arfiadi

Recommendation systems are one of the most powerful application of machine learning for online markets. To illustrate how to leverage big data of customer transactions and make recommendations effectively, we experimented with multiple algorithms including K-Nearest-Neighbor (KNN), Association Rules, and Item-Item Collaborative Filtering. Our dataset details 3 million transactions, including items purchased, items reordered, and the time of the last order. This became our biggest challenge as it takes a significantly large amount of computing power to process all of the data. As a result, we had to experiment with various machine learning algorithms.

■ MC28

CC- Room 4C-3

Service Operation and its Application

Sponsored: Service Science

Sponsored Session

Chair: Niratcha Tungtisanont, University of Maryland, College Park, MD, 20742, United States

1 - Impact of Standardization Versus Customization Operational Strategy on Nursing Home Performance

Lu Kong, Cornell University, Ithaca, NY, 14850, United States, Kejia Hu, Rohit Verma

In this paper, we explore the impact of standardization versus customization operational strategy on nursing home performance. We quantify the degree of standardization of each nursing home relative to its chain norm, and the results demonstrate that the degree of standardization on service offering and delivering is positively related to the outcomes, while standardization level of market mix is negatively related.

2 - Identifying Perceived Customer Value for Wellness-centric Features in Hospitality: Evidence From EEG Signals

Min Kyung Lee, Assistant Professor, Northern Illinois University, DeKalb, IL, United States, mlee12@niu.edu, Aleda Roth, Oriana Aragon

This paper explores customers' perceived value that is attributable to the presence or absence of wellness-centric offerings in a hotel room. For semantic clarity, we employ the term "wellness-centric" to connote a bundle of new service design features that are specifically embedded within a hotel room environment and which act passively to improve hotel guests' physical and emotional well-being during their stay. In an experimental design we tested the contribution of wellness-centric offerings in value creation through an electroencephalogram (EEG) laboratory experiment with measured self-report and neural indices of "wanting."

3 - Is Standardization Always Good for Patient Outcomes? The Moderating Role of Operational Failures

Sarah Zheng, University of Victoria, Victoria, BC, Canada, Anita Tucker

Using survey data from 292 medical or surgical nursing units at 63 hospitals across the States, we found that when Operations Failure is high, the level of standardization is negatively associated with Hospital Acquired Pressured Injuries, suggesting that a high level of the standardization will benefit patient outcome. However, When Operational Failure is low, the increase of standardization may not benefit patient outcome if not bring harm to.

4 - Innovations in Humanitarian Operations: Investigating Flood Disaster Recovery Through the Len of Services Operation

Niratcha Tungtisanont, University of Maryland, College Park, LBPP Dept., College Park, MD, 20742, United States, Aleda Roth

This study examines humanitarian operations and crisis management (HOCM) in a way that influences policy. The primary goal of this research is to adopt the lens of strategic service operations in conceptualizing how best to design and prioritize strategic choices (e.g., resources, investments, policy, etc.) prior to and during a flood event in order to enhance the overall effectiveness of the recovery process. We draw upon the service strategy literature, we consider the roles of various stakeholders—individuals, communities, and governments—in the co-production disaster relief services and activities.

5 - Intermediation under the Overlapping Generations of Technology: An Empirical Study of MVNO

Fan Zou, University of South Carolina, Columbia, SC, United States, An Dong, Keija Hu, Sriram Venkataraman

This study examines the impact of mobile virtual network operators (MVNOs) on the performance of mobile network operators (MNOs) with the presence of overlapping generations of wireless mobile technologies (2G and 3G). MVNOs are an innovative business that works with MNOs to provide mobile services to customers without owning any spectrum or network infrastructures. Some MVNOs are wholly owned by MNOs with a revenue-sharing mechanism (Branded MVNO), while others only obtain service from MNOs through wholesale agreements (Third-party MVNO). By exploring the impact of MVNOs on MNOs' performance, we extend our understanding of intermediation in the presence of overlapping generations of products, as well as how it interacts with the ownership of the intermediaries. This study also provides valuable guidance for managers of MNOs in the use of MVNO.

■ MC29

CC- Room 4C-4

Joint Session AMD/Practice Curated: Dynamic Matching Market Design

Sponsored: Auction and Market Design

Sponsored Session

Chair: John P. Dickerson, University of Maryland, College Park, MD, 20742, United States

1 - Incorporating Compatible Pairs in Kidney Exchange: A Dynamic Weighted Matching Model

Sanmay Das, Washington University in St. Louis, Dept. of Computer Science & Engr., Saint Louis, MO, 63130, United States, Zhuoshu Li, Kelsey Lieberman, William Macke, Sofia Carrillo, Chien-Ju Ho, Jason Wellen

We study a hybrid online/batch matching model with impatient and patient pairs to capture the dynamics of kidney exchanges that could include compatible pairs. We introduce new algorithms for matching in this model and apply them to graphs generated from a novel simulator for the joint distribution of compatibility and match quality (for which we leverage the recently proposed LKDPI) across pairs. Our results indicate great potential in terms of both increased numbers of transplants of incompatible pairs as well as improved match quality for recipients in compatible pairs.

2 - On Tanking and Competitive Balance

Aleksandr Kazachkov, Polytechnique Montreal, Montreal, QC, Canada, Shai Vardi

Tanking is a phenomenon in sports in which teams attempt to purposefully lose games. We analyze the perverse incentives that lead to tanking and propose a new bilevel mechanism for ranking teams that can drastically reduce tanking behavior, which we support with theoretical and experimental results.

3 - Design of Lotteries and Waitlists for Affordable Housing Allocation

Peng Shi, University of Southern California, Los Angeles, CA, 90064, United States, pengshi@usc.edu, Nicholas A. Arnosti

We study a stylized model of assigning items to dynamically arriving items, in which an ideal mechanism both target items to agents with the worst outside options, and match them to items for which they have high value. We find that two common approaches — using independent lotteries for each item, and using a wait-list in which agents lose priority when they reject an offer — lead to identical outcomes in equilibrium. The match quality can be improved by using a common lottery for all items. If participation costs are negligible, a common lottery is equivalent to limiting participants to a single lottery, using a wait-list in which offers can be rejected without punishment, or using artificial currency.

■ MC29a

CC- Room 400

Information, Investment, and Risk Management

Sponsored: Finance

Sponsored Session

Chair: Nan Chen, Chinese University of Hong Kong, Shatin N T, Hong Kong

1 - Dynamic Investment and Financing with Internal and External Liquidity Management

Nan Chen, Chinese University of Hong Kong, William M. W. Mong Engineering Bldg, Shatin N. T, Hong Kong, nchen@se.cuhk.edu.hk, Yuan Tian, Jiahui Ji

We develop a theoretical model of dynamic investments, dividend payouts, debt borrowing, external equity financing, and bankruptcy for financially constrained firms. The model characterizes the central importance of liquidity management in corporate decision making in the presence of external financing costs. The paper also discusses the implications of liquidity and leverage requirements in the current banking regulatory framework.

2 - Systemic Portfolio Diversification

Agostino Capponi, Columbia University, New York, NY, 10027, United States, ac3827@columbia.edu

We study the implications of fire-sale externalities on balance sheet composition. Banks select their asset holdings to minimize expected execution costs triggered by the need to comply with regulatory leverage requirements. We show that if banks disregard the price impact caused by other banks' liquidation actions, they hold an excessively diversified portfolio. Banks seek systemic diversification when they account for the negative externalities imposed by other banks' liquidation actions. Social costs can be reduced by a tax on portfolio overlap, or by enforcing policies which mandate the split of a bank into smaller institutions with heterogeneous leverage ratios.

3 - Dynamic Information Regimes in Financial Markets

Yiwen Shen, PhD Candidate, Columbia Business School, New York, NY, 10025, United States, YShen21@gsb.columbia.edu, Paul Glasserman, Harry Mamaysky

We develop a dynamic model of information and prices where investor information choices influence level of available public and private information about fundamentals. We study two feedbacks. In the first, more informed investors make more information of fundamentals become available. Consequently, two regimes emerge, one with higher prices and lower volatility, and one with lower prices and higher volatility. Information dynamics move market between regimes, creating large market drops and rallies, with no fundamental change. In the second feedback, an increase in the number of informed investors leads to greater public information through leakage; this mechanism has a stabilizing effect.

4 - Investment Valuations and Falling Cost of Information

Hong Ming Tan, National University of Singapore, Singapore, 127146, Singapore, thm@u.nus.edu, Jussi Keppo

We model two risk-averse decision makers who optimize the size of their investment, and the level of costly information on the investment. The decision makers affect the market price of the investment, and optimize their own expected utility given the other decision maker's quantity of information. Therefore we study the resulting market equilibrium. We show that in this game model, the falling cost of information raises the Nash equilibrium quantity of information for each decision maker. This results in an increase in the expected equilibrium price of the investment, i.e., the falling cost of information raises the cost of investments. We show empirical evidence for this by using U.S. equity prices.

■ MC30

CC- Room 6A

Tutorial: Recent Advances in Multi-Armed Bandits for Sequential Decision Making

Emerging Topic: Tutorials

1 - Recent Advances in Multi-armed Bandits for Sequential Decision Making

Shipra Agrawal, Columbia University, Industrial Engnr. and OR, New York, NY, 10027, United States

This tutorial discusses some recent advances in sequential decision making models that build upon the basic multi-armed bandit (MAB) setting to greatly expand its purview. Specifically, it discusses progress in algorithm design and analysis techniques for three models: (a) Contextual bandits, (b) Combinatorial bandits, and (c) Bandits with long-term constraints and non-additive rewards, along with applications in several domains such as online advertising, recommendation systems, crowdsourcing, healthcare, network routing, assortment optimization, revenue management, and resource allocation.

■ MC31

CC- Room 6B

Decision-making Under Uncertainty

Sponsored: Military and Security

Sponsored Session

Chair: Phillip Rolland Jenkins, USAF, Dayton, OH, 45424, United States

Co-Chair: Brian J. Lunday, Air Force Institute of Technology, WPAFB, OH, 45433, United States

1 - Robust Influence Modeling under Structural and Parametric Uncertainty: An Afghan Counter Narcotics Use Case

Brian J. Lunday, Air Force Institute of Technology, Department of Operational Sciences, WPAFB, OH, 45433, United States, brian.lunday@afit.edu, William Nicholas Caballero

An entity often wishes to influence the decisions of others in a system. However, the central task of this entity is confounded by uncertainty regarding their understanding of the structure and/or parameters of the decisions being made. This research sets forth a modeling framework to identify robust influence strategies under uncertain conditions. Its utility and proper parameterization are illustrated via an application to Afghan opium cultivation. Utilizing open source data, we demonstrate how counternarcotic policy can be informed using a quantitative analysis that embraces both decisionmaker bounded rationality and uncertainty regarding the degree of this deviation from rationality.

2 - Understanding the Learning Behavior of Terrorist Organizations

Gilberto Montibeller, Loughborough University, School of Business & Economics, Loughborough, United Kingdom, g.montibeller@lboro.ac.uk, Johannes Jaspersen

There is evidence that terrorists are both adaptive in their behavior and driven by multiple objectives in their actions. In this paper, we use insights from the adaptive learning theory and compare several different reinforcement learning models regarding both their psychological implications and their fit to empirical data. Using data on target choices of terrorist attacks and two different objectives (renown and revenge), we show that a total reinforcement learning with power choice probabilities and information discounting can be used to model the adaptive decision process of terrorists. We draw implications for counter-terrorism strategies by comparing it with other behavioral models.

3 - Counterfactual Regret Minimization for Integrated Cyber and Air Defense Allocation

Andrew Keith, Air Force Institute of Technology, 5173 Gander Rd W, Dayton, OH, 45424, United States, Darryl K. Ahner

We present a new application of optimal and approximate solution techniques to an integrated cyber and air defense problem. To model this problem, we use an extensive-form game with imperfect information for an attacker and defender in physical and cyber space. To determine optimal defender strategies, we reformulate the problem to find a Nash equilibrium using a sequence-form linear program. We also develop a fast application of counterfactual regret minimization and characterize the optimality gap. Lastly, we quantify the value of improved situational awareness in the cyber domain and present an extension to robust solution techniques that address ambiguity in the game model.

4 - Robust Multi Objective Optimization for the Military Medical Evacuation Location Allocation Problem

Phillip Rolland Jenkins, Air Force Institute of Technology, Dayton, OH, 45424, United States, Brian J. Lunday, Matthew J. Robbins

Determining where to locate mobile aeromedical staging facilities (MASFs) as well as identifying how many aeromedical helicopters to allocate to each MASF, commonly referred to as the medical evacuation (MEDEVAC) location-allocation problem, is vital to the success of a deployed MEDEVAC system. We develop an integer mathematical programming formulation to determine the location and allocation of MEDEVAC assets over the phases of a military deployment to support operations ranging from peacekeeping through combat to post-combat resolution and to analyze trade-offs between three competing objectives.

5 - Generating Robust Patrol Patterns Through Fictitious Play

Richard G. McGrath, Military Professor, United States Naval Academy, Annapolis, MD, United States

We present a problem where a patroller wants to determine a strategy that minimizes the expected cost of an attack by an intelligent enemy. We generate patrol patterns against a strategic attacker using the game-theoretic method of fictitious play, which is an iterative method used to create mixed strategies in a two-person zero-sum game. Each player arbitrarily chooses a pure strategy in the first round; and in subsequent rounds, each player chooses a pure strategy that will produce the best expected value against the mixture of strategies used by the other player in previous rounds. Numerical experiments demonstrate that this method produces excellent results when compared to the optimal solution.

■ MC32

CC- Room 6C

Health Care, Modeling and Optimization VII

Contributed Session

Chair: Maryam Keshtzari, Texas Tech University, Texas, Lubbock, TX, 79416, United States

1 - A Memetic Algorithm for Solving Optimal Control Problems of Zika Virus Epidemic with Equilibriums and Backward Bifurcation Analysis

Kaiming Bi, Kansas State University, Manhattan, KS, United States, bikaiming@ksu.edu

This research utilizes an existed mathematics model in the Zika virus, then analyzes the stability and bifurcation. Consequently, we have established an Optimal Control problem associated with the model based on several popular disease intervention strategies frequently used by public health agencies to mitigate the Zika epidemics. Comparisons of traditional Pontryagin's maximum principle and memetic algorithm were conducted for different intervention strategies. Also, this research mentioned theoretical continuous optimal control might not be practical. Rather, the MA-based discrete is relatively easy to be implemented in real-world applications.

2 - Network-based Analysis and Optimization for Scheduling Pharmacists and Technicians

Phichet Wutthisirisart, Senior Health Services Analyst, Mayo Clinic, Rochester, MN, United States, Kalyan Pasupathy, Desirae Sagdalen, Brent Ferguson, Lynnette Nelson, Mustafa Y. Sir

With the goals of speeding up completion time and ensuring increased staff utilization, the health system pharmacy allows various steps of an order to be processed at multiple service locations, linked through the order management software. We developed an optimization model to help the Mayo Clinic Pharmacy assess the performance of staff schedule templates, and identify the optimal plan that minimizes the total delay. The model is created as a network-based MRP and includes practical constraints such as staff-type ratio, role-dependent task, and break-times. It was applied to evaluate the current schedule, provide an optimal plan, and compare options of adding staff and speeding up a certain task.

3 - Impact of Customer Concealment Behavior on Health Insurance Choices under Asymmetric Information

Huan Sun, PhD Candidate, Southeast University, Nanjing, China, jingran2009@163.com, Haiyan Wang

In mainstream health control systems, customers pay insurance premiums to healthcare system at regular intervals, while healthcare system provide health services. However, that may lead to patient's information-hidden behavior for less payment, which harms the interests of health system. To reduce the inefficiencies positively, we design a series of health insurance plans to guide differentiated consumers choose plans which not only meet their needs but also reduce health system's cost. Our results suggest health system to focus on the inflection point of price impact on customer's utility when setting up plans.

4 - Designing a Telemedicine Network with Doctors Serving Walk-in and Network Patients

Behnaz Hosseini, PhD, National University of Singapore, Singapore, Singapore, Baris Tan

We present a stochastic model to design a telemedicine network that consists of a number of doctors who serve their walk-in patients in person and, also receive the online medical requests directed from a telemedicine network. In order to develop the model, we start with the dynamic admission control problem for the doctors who decide how to admit the walk-in and the network patients. We then analyze the operation of the whole network and obtain the optimal number of doctors to maximize the network's profit and offer the desired service level. We show that a telemedicine network is an effective way of utilizing the idle capacity of the doctors while providing a high service level to the network patients.

5 - Solving a Home Health Care Routing and Scheduling Problem with a Fix-and-optimize Matheuristic

Luciana S. Buriol, Federal University of Rio Grande do Sul, Porto Alegre, Brazil, Alberto Kummer Neto, Olinto Araújo

The Home Health Care Routing and Scheduling Problem (HHCRSP) consists of the routing and scheduling a set of personnel to fulfill health attendance to home patients. HHCRSP is basically a vehicle routing problem with time windows that includes space-time constraints to cope with route synchronization requirements. Vehicles represent the personnel and the nodes represent patients waiting for attendance. The Fix-and-Optimize matheuristic decomposes the problem into subproblems solved via MIP. We tested our approach in an online available dataset, and in realistic instances that we generated. Preliminary results demonstrate the efficiency of the proposed approach in solving the problem.

6 - Capacity Planning in Oncology Clinics

Maryam Keshtzari, Texas Tech University, Lubbock, TX, United States, maryam.keshtzari@ttu.edu, Bryan A. Norman

Oncologists are specialized in certain cancer types based on their professional and academic interests. As a result, the overall clinic capacity may not necessarily match the actual demand for different cancer types. The objective of this study is to propose a mathematical model to create a specialization mix to balance the workload across oncologists and minimize patient wait time. Uncertainty regarding new patient demand and returning patients' treatment plans are considered.

■ MC33

CC- Room 602

JuMP 3 - Applications

Sponsored: Optimization/Computational Optimization and Software

Sponsored Session

Chair: Oscar Dowson, Northwestern University, Northwestern, IL, United States

1 - WaterModels.jl: An Open-source Framework for Exploring Water Network Optimization Formulations

Byron Tasseff, Scientist, Los Alamos National Laboratory, Los Alamos, NM, United States, btasseff@lanl.gov, University of Michigan, Ann Arbor, MI, United States, btasseff@lanl.gov, Russell Bent, Carleton Coffrin

Water distribution system optimization problems are characterized by non-convex physics and discrete decisions. Because of these challenges, a variety of mathematical programming techniques have been developed to increase tractability. However, the large number and disparity of these techniques present barriers to effectively evaluating them over a large set of applications. To address this issue, this work introduces WaterModels, an open-source platform based on JuMP for comparing water distribution system optimization formulations. To demonstrate its effectiveness, a proof of concept study evaluating various methods for water network design and pump scheduling is presented.

2 - Alpine.jl a JuMP Based Solver for Global Optimization of MINLPs

Harsha Nagarajan, Los Alamos National Laboratory, Los Alamos, NM, 87544, United States, harsha@lanl.gov, Russell Bent, Kaarthik Sundar

MINLPs arise in practical applications such as synthesis of process and water networks, energy infrastructure networks, to name a few. Efficient algorithms to solve such optimization problems to global optimality is a key to addressing these applications. We present Alpine.jl, a JuMP-based global optimization solver which leverages MILP-based approaches, constraint programming techniques and efficient piecewise polyhedral formulations to efficiently solve the fairly large-scale MINLPs. Finally, we provide extensive numerical benchmarking of Alpine in comparison with Baron, SCIP and Couenne.

3 - Powersimulations.jl a Integrated and Scalable Power Systems Optimization Modeling Framework

Jose Daniel Lara, University of California Berkeley, Berkeley, CA, United States, jdlara@berkeley.edu

PowerSimulations.jl uses core concepts of mathematical programming to develop a framework that exploits the structure of power systems problems to build optimization models. The proposed solution is based on the specification of a meta-model to inform the systematic construction of the optimization problem. The systematic approach for formulating power systems models, provides flexibility, modularity, and scalability to the user. This approach is enabled by several JuMP features such as containers, affine and quadratic expressions, problem modification and MOI bridges. This talk will showcase the application of these features to large-scale power systems model specifications.

4 - Jump Automatic Dualization

Guilherme Bodin, PUC-Rio, Rio de Janeiro, Brazil, gbodin@ele.puc-rio.br, Joaquim Garcia

The JuMP automatic dualization feature helps users to exploit different formulations of their optimization problems rapidly. The functionality can dualize any conic convex optimization problem. Moreover, automatic dualization can simplify the modeling of bilevel problems by automatically building KKT conditions. In this talk, we will show how it was done and some examples where the automatic dualization enters in other JuMP related packages.

5 - Regularization in Expectation-Maximization Clustering

Thibaut Vidal, PUC-Rio, Rua Marques de Sao Vicente, 225, Rio de Janeiro, 22453-900, Brazil, Raphael Sampaio, Joaquim Dias Garcia, Marcus Poggi

We introduce several variants of the well-known Expectation-Maximization (EM) algorithm for Gaussian mixture-based clustering. These methods differ in their use of regularization techniques during covariance matrix estimation, and in terms of the amount of effort spent searching for better local minima. Sophisticated global optimization methods, in particular, appear to need some regularization to be truly beneficial. We provide an open-source implementation in Julia, using the JuMP modeling language for mathematical optimization.

6 - An Exact and Scalable Problem Decomposition for Security-Constrained Optimal Power Flow using JuMP

Alexandre Velloso, Pontifical Catholic University, Rio de janeiro, Brazil, Pascal Van Hentenryck, Emma Johnson

This paper presents dedicated constraint and cutgeneration procedures for solving large-scale instances of thesecurity-constrained optimal power flow (SCOPF) problem fea-turing proportional reserve response. Specifically, under eachcontingency state, the SCOPF requires that the nodal demandsare met and that the units generating below their maximumcapacity use exactly the same proportion of their reserves. Theresulting model is formulated as an instance of mixed-integerlinear program. Unfortunately, solution methods relying ontraditional Benders decomposition do not scale to large instances.To address this limitation, the paper proposes an iterative three-step algorithm involving 1) a relaxed SCOPF problem with validpost-contingency generation-related constraints; 2) an exogenousnumerical scheme for refining the post-contingency generation;and 3) procedures for selecting dedicated cuts and disjunctiveconstraints to restrict the relaxed SCOPF problem. The paperalso discusses numerical issues, heuristics and valid bounds forthe method. Finally, the efficiency of the proposed method isdemonstrated on large-scale case studies.

■ MC34

CC- Room 603

Recent Advances in Distributed Optimization

Sponsored: Optimization/Global Optimization

Sponsored Session

Chair: Andy Sun, Georgia Institute of Technology, Atlanta, GA, 30332-0205, United States

1 - A Distributed ADMM-like Method for Resource Sharing Over Time-varying Networks

Erfan Y. Yazdandoost Hamedani, Pennsylvania State University, University Park, PA, United States, evy5047@psu.edu, Necdet Serhat Aybat

We consider cooperative multi-agent resource sharing problems over time-varying communication networks, where only local communications are allowed. The objective is to minimize the sum of agent-specific composite convex functions subject to a conic constraint that couples agents' decisions. We propose a distributed primal-dual algorithm DPDA-D to solve the saddle point formulation of the sharing problem on time-varying (un)directed communication networks; and we provide convergence rates for suboptimality, infeasibility and consensus violation of agents' dual price; examine the effect of underlying network topology on the convergence rates of the proposed decentralized algorithm.

2 - Asymptotic Network Independence in Distributed Optimization

Alex Olshevsky, Boston University, Boston, MA, 60657, United States, alexols@bu.edu

We consider stochastic gradient descent in a network of n nodes: every node knows a strongly convex function, and the goal is to compute the minimizer of the sum of these n functions. At each time step, every node can broadcast a message to its neighbors in a (directed) network and query its own function for a noisy gradient. We describe a method which has the propertythat we call asymptotic network independence: in the limit, the distributed system converges to the global minimizer as fast as a centralized method that can obtain all of the n of the noisy gradients at every time step.

3 - Two-level Distributed Algorithms for Nonconvex Nonsmooth Optimization with Applications in Sparse Regression

Kaizhao Sun, Georgia Institute of Technology, Atlanta, GA, 30318, United States, Andy Sun

In this talk, we present some new distributed algorithms for solving large-scale nonconvex nonsmooth problems with convergence guarantees. We present a two-level algorithmic framework where the inner level is a reformulated multi-block ADMM and the outer level is an augmented Lagrangian model with safeguarding dual variable update. We study the performance of sequential and Jacobi-type ADMM and their inexact proximal variants, and demonstrate the superior performance of these two-level algorithms to the one-level ADMM in sparse regression problems.

4- Complexity of Highly Parallel Non-Smooth Convex Optimization

Sebastien Bubeck, Microsoft Research, Redmond, WA, United States

A landmark result of non-smooth convex optimization is that gradient descent is an optimal algorithm whenever the number of computed gradients is smaller than the dimension d. In this paper we study the extension of this result to the parallel optimization setting. Namely we consider optimization algorithms interacting with a highly parallel gradient oracle, that is one that can answer poly(d) gradient queries in parallel. We show that in this case gradient descent is optimal only up to d^1/2 rounds of interactions with the oracle. The lower bound improves upon a decades old construction by Nemirovski which proves optimality only up to d^1/3 rounds (as recently observed by Balkanski and Singer), and the suboptimality of gradient descent after d^1/2 rounds was already observed by Duchi, Bartlett and Wainwright. In the latter regime we propose a new method with improved complexity, which we conjecture to be optimal. The analysis of this new method is based upon a generalized version of the recent results on optimal acceleration for highly smooth convex optimization.

■ MC35

CC- Room 604

Bridging Discrete and Continuous Optimization

Sponsored: Optimization/Integer and Discrete Optimization

Sponsored Session

Chair: Swati Gupta, Georgia Institute of Technology, Atlanta, GA, 30332, United States

1 - New Methods for Regularization Path Optimization via Differential Equations

Heyuan Liu, University of California, Berkeley, CA, 94720-1777, United States, heyuan_liu@berkeley.edu, Paul Grigas

We develop and analyze several different second order algorithms for computing an approximately optimal solution/regularization path of a parameterized convex optimization problem with smooth Hessian. Our algorithms are inspired by a differential equations perspective on the parametric solution path and do not rely on the specific structure of the regularizer. We present computational guarantees that bound the oracle complexity to achieve an approximately optimal solution path under different sets of smoothness assumptions and that also hold in the presence of approximate subproblem solutions.

2 - Binarization in Integer Programming and Nonlinear Programming

Robert Hildebrand, Virginia Tech, Blacksburg, VA, 24061, United States, rhil@vt.edu

We look at how converting variables to binary variables, either through a descritization trick or through a reformulation of integrality, can drastically improve a model. We will look at the theory behind these ideas and also some numerical results.

3 - Distributed Algorithms for Fair Packing and Covering Problems

Jelena Diakonikolas, UC Berkeley, Berkeley, CA, United States, Maryam Fazel, Lorenzo Orecchia

Over the past decades, an axiomatic approach to fair resource allocation has led to the general acceptance of a class of alpha-fair utilities parametrized by a single non-negative parameter alpha. The maximization of alpha-fair utilities is typically considered subject to positive linear (packing) constraints. In this talk, I will present distributed and width-independent first-order methods for solving general alpha-fair packing problems and their minimization counterparts — alpha-fair covering problems. The convergence times of these algorithms scale as Õ(1/eps2) and Õ(1/eps), greatly improving upon Õ(1/eps5) and Õ(1/eps4) previously known only for the alpha-fair packing problems.

4 - On Sufficient and Necessary Conditions for Rank-1 Generatedness Property of Cones

Fatma Kilinc-Karzan, Associate Professor of Operations Research, Carnegie Mellon University, Pittsburgh, PA, United States, fkilinc@andrew.cmu.edu, CJ Argue

A convex cone K that is a subset of the positive semidefinite (PSD) cone is rank-one generated (ROG) if all of its extreme rays are generated by rank 1 matrices. ROG property is closely related to the characterizations of exactness of SDP relaxations, e.g., of nonconvex quadratic programs. We consider the case when K is obtained as the intersection of the PSD cone with finitely many linear (or conic) matrix inequalities, and identify sufficient conditions that guarantee that K is ROG. In the case of two linear matrix inequalities, we also establish the necessity of our sufficient condition.

■ MC36

CC- Room 605

On Prediction and Optimization

Sponsored: Optimization/Optimization Under Uncertainty

Sponsored Session

Chair: Fatma Kilinc Karzan, Carnegie Mellon University, Pittsburgh, PA, 15217, United States

Co-Chair: Nam Ho-Nguyen, Carnegie Mellon University, Pittsburgh, PA, 15213, United States

1 - Risk Guarantees for End-to-end Prediction and Optimization Processes

Nam Ho-Nguyen, Carnegie Mellon University, Tepper PhD Program, Pittsburgh, PA, 15213, United States, Fatma Kilinc Karzan

In real-world decision-making, prediction models are often used to estimating parameters of optimization models. While it is usually believed that good prediction performance should result in good subsequent optimization performance, formal theoretical guarantees on this are lacking entirely. We provide two sufficient conditions on the prediction loss function that good prediction results in good optimization, and derive explicit relations between the two. In a preliminary computational study on fractional knapsack problems, we compare the optimization performance of using several Fisher consistent prediction loss functions with a provably inconsistent loss function.

2 - Generalization Bounds in the Predict-then-Optimize Framework

Paul Grigas, University of California, Berkeley, CA, 94720-1777, United States, pgrigas@berkeley.edu, Othman El Balghiti, Adam Elmachtoub, Ambuj Tewari

In the predict-then-optimize environment, the parameters of an optimization task are predicted based on contextual features. A natural loss function in this setting, called the Smart Predict-then-Optimize (SPO) loss, is to consider the cost of the decisions induced by the predicted parameters, in contrast to the prediction error of the parameters. We provide an assortment of novel generalization bounds for the SPO loss function, including initial bounds based on a combinatorial complexity measure and substantially improved bounds under an additional strong convexity assumption.

3 - Statistically-Consistent Identification of Switched Linear Systems

Pedro Ivo Bastos Hespanhol, UC Berkeley, Berkeley, CA, 94709, United States, pedrohespanhol@berkeley.edu, Anil Aswani

Consider a set of linear autonomous systems with bounded process noise, where the system dynamics are unknown. A question is how to estimate the system dynamics given that measurements of each system are nonsequential. Though seemingly straightforward, existing proof techniques for statistical consistency of system identification fail when measurements are nonsequential. Here, we provide an estimator that leverages boundedness of the process noise, and we prove its statistical consistency holds even when measurements are nonsequential. We illustrate the almost sure convergence of our estimator by using it to construct a stabilizing policy for a learning-based switched control application.

4 - Differentiable Optimization Based Modeling for Machine Learning

Brandon Amos, Carnegie Mellon University, Pittsburgh, PA, United States, brandon.amos.cs@gmail.com

Domain-specific modeling priors and specialized components are important for machine learning to integrate specialized knowledge into the model. We argue that optimization methods provide an expressive set of operations that should be part of the machine learning practitioner's modeling toolbox. We will present the OptNet architecture that integrates optimization problems as layers in larger trainable networks. We then show how this can be used to combine model-free and model-based reinforcement learning. Lastly we will present a way of rapidly prototyping differentiable optimization layers with cvxpy.

■ MC37

CC- Room 606

Robust Optimization: Theory and Applications

Sponsored: Optimization/Optimization Under Uncertainty

Sponsored Session

Chair: Vineet Goyal, Columbia University, New York, NY, 10027, United States

1 - On the Optimality of Affine Policies for Budgeted Uncertainty Sets

Omar El Housni, Columbia University, New York, NY, 10027, United States, oe2148@columbia.edu, Vineet Goyal

We study the performance of affine policies for two-stage adjustable robust optimization problem under a budget of uncertainty set. The two-stage adjustable robust optimization problem is hard to approximate within a factor better than $\Omega(\frac{\log n}{\log \log n})$ for budget of uncertainty sets where n is the number of decision variables. We show that surprisingly affine policies provide the optimal approximation for this class of uncertainty sets that matches the hardness of approximation; thereby, further confirming the power of affine policies. We also provide a faster algorithm to compute near-optimal affine policies.

2 - Optimal Monitoring with Limited Information

Dan Andrei Iancu, INSEAD and Stanford University, Stanford, CA, 94107, United States, daniancu@stanford.edu, Do Young Yoon, Nikolaos Trichakis

We consider problems where a system can only be stopped at a limited set of monitoring times, which must be chosen in conjunction with the stopping policy. In a framework where only limited information is available — namely, ranges of future values — and where monitoring reduces uncertainty, we show that the worst-case rewards under static and dynamic monitoring are the same, under broad conditions. We show how this allows recovering an optimal dynamic policy by resolving static problems, and discuss cases when the latter problems are tractable, highlighting conditions when simple monitoring schedules (e.g., with equi-distant times) are optimal.

3 - A First-order Method for Robust Optimization Problems

Shimrit Shtern, Technion - Israel Institute of Technology, William Davidson Faculty of Industrial E, Haifa, 32000, Israel, shimrits@technion.ac.il, Krzysztof Postek

In this work, we suggest a first-order saddle-point approach for solving large-scale robust optimization problems where each constraints is convex in the decision variables and concave in the uncertain parameters. This method does not require boundedness of the primal variables and enables dealing with complex uncertainty sets. The suggested method has an O(1/T) convergence rate with both optimality and feasibility guarantees.

■ MC38

CC- Room 607

Two-Stage Distributionally Robust Optimization and its Applications in Power Systems

Sponsored: Optimization/Optimization Under Uncertainty

Sponsored Session

Chair: Chaoyue Zhao, Oklahoma State University, Stillwater, OK, 74075, United States

1 - The Supermodularity in Two-stage Distributionally Robust Optimization

Aiqi Zhang, The Chinese University of Hong Kong, Hong Kong, aqzhang@se.cuhk.edu.hk, Daniel Zhuoyu Long, Jin Qi

In this paper, we solve a class of two-stage distributionally robust optimization problems equipped with the property of supermodular. We derive the exact worst-case distribution in the robust counterpart which leads to the tractability of this class of problems. We further provide a necessary and sufficient condition to check if any given two-stage optimization problem has supermodular property. We apply this framework to classical problems, including multi-item newsvendor problems, general assemble-to-order systems and the appointment scheduling problem. While typically these problems are computationally challenging, they can be solved efficiently with our approach.

2 - A Data-driven Model of Virtual Power Plants in Day-ahead Unit Commitment

Sadra Babaei, Oklahoma State University, 322 Engineering North, Industrial Engineering & Mgmt, Stillwater, OK, 74078, United States, sadra.babaei@okstate.edu

Due to the increasing penetration of Distributed Energy Resources (DERs), power system operators face challenges of ensuring effective integration of DERs. The Virtual Power Plant (VPP) enables DERs to provide their services by aggregating them and participating in the wholesale market as a single entity. However, the available capacity of VPP depends on its DER outputs, which is time-varying and not exactly known when the independent system operator runs the day-ahead unit commitment engine. This talk proposes a data-driven model to evaluate the physical characteristics of the VPP, i.e., maximum capacity and ramping capabilities, given the uncertainty in wind power output and load consumption.

3 - Distributionally Robust Reliability Assessment for Transmission System Hardening Plan under N-k Security Criterion

Ali Bagheri, Oklahoma State University, Stillwater, OK, 74075-5757, United States

Hardening and reliability assessment of power transmission networks have become very important to make power systems less vulnerable to cascading failures. To do a reliability assessment, the information of contingency probabilities are required. However, such information is usually unknown and cannot be estimated precisely. Thus, we assume the probability of contingencies unknown and ambiguous. Besides, the commonly used N-1 security criterion does not guarantee the system reliability against possible cascading failures. In this study, given a hardening plan, we develop two distributionally robust models to evaluate the reliability of transmission system under N-k security criterion.

4 - Distributionally Robust Distribution Network Configuration under Random Contingency

Chaoyue Zhao, Oklahoma State University, Stillwater, OK, 74075, United States

Topology design is a critical task for the reliability, economic operation, and resilience of distribution systems. This work proposes a distributionally robust optimization (DRO) model for designing the topology of a new distribution system facing random contingencies. The proposed DRO model optimally configures the network topology and integrates distributed generation to effectively meet the loads. As compared with a classical robust optimization model, the DRO model explicitly considers the contingency uncertainty and so provides a less conservative configuration, yielding a better out-of-sample performance.

■ MC39

CC- Room 608

Round Table - Discussion

Sponsored: Railway Applications

Sponsored Session

Chair: Jeremiah Dirnberger, GE Transportation, Jacksonville, FL, 32217, United States

Moderator

Jeremiah Dirnberger, Wabtec Corporation, 7572 Old Kings Road South, Jacksonville, FL, 32217, United States, jeremiah.dirnberger@wabtec.com

Positive Train Control (PTC) is one of the largest infrastructure projects ever undertaken by a single industry. Mandated by the U.S. government, PTC aims to further reduce the risk of accidents on the nation's rail network. The amount of data collected for the operation of this system is unprecedented and the industry is looking to leverage it to create the backbone of a digital railroad. In these panels, experts from several leading will discuss the potentials within this new data, how it is already being used, the opportunity for data scientists and operations researchers, and its role in the path toward automation in the rail industry.

Panelist

- Larry Chalmers
- Marty Schlenker, BNSF Railway, Fort Worth, TX, United States
- Patricia Randall, Princeton Consultants, Greenville, SC, 29605, United States
- Steven Harrod, Technical University of Denmark, Lyngby, 2800, Denmark

■ MC40

CC- Room 609

Primal-Dual First-Order Methods

Sponsored: Optimization/Nonlinear Programming

Sponsored Session

Chair: Renbo Zhao, ORC, MIT, Cambridge, MA, 02142, United States

1 - On the Convergence of Primal-dual First-order Methods for Min-max Non-convex Optimization

Songtao Lu, AI Resident, IBM Research, Yorktown Heights, NY, 55414, United States, lus@umn.edu

In this work, we consider a general block-wise one-sided non-convex min-max problem, in which the minimization problem consists of multiple blocks and is non-convex, while the maximization problem is (strongly) concave. We propose a class of simple algorithms named hybrid block successive approximation (HiBSA), which alternatingly performs gradient descent-type steps for the minimization blocks and one gradient ascent-type step for the maximization problem. For the first time, we show that such simple alternating min-max algorithms converge to first-order stationary solutions, with quantifiable global rates.

2 - Radial Duality

Benjamin Grimmer, Cornell University, Ithaca, NY, 14850, United States, bdg79@cornell.edu

Recently Renegar introduced a radial transformation which turns generic convex optimization problems into unconstrained, uniformly Lipschitz continuous ones. We generalize this transformation to avoid any reliance on convexity and thus apply to a variety of nonconvex functions. Our alternative construction shows this transformation is dual (i.e., self-inverse), which gives structural insights relating primal and radially dual problems. We characterize when the radially dual problem is uniformly Lipschitz or smoothness. Hence, this radial duality provides a strong foundation analyzing radial variations of the subgradient and accelerated methods for both convex and nonconvex problems.

3 - A Unifying Framework for Variance Reduction Algorithms for Finding Zeroes of Monotone Operators

Xun Zhang, PhD Candidate, National University of Singapore, Singapore, e0225088@u.nus.edu, Zhi-Sheng Ye, William Haskell

A wide range of optimization problems can be recast as monotone inclusion problems. We propose a unifying framework for solving the monotone inclusion problem with randomized Forward-Backward algorithms. Our framework covers many existing deterministic and stochastic algorithms. Under various conditions, we can establish both sublinear and linear convergence rates in expectation for the algorithms covered by this framework. In addition, we consider algorithm design as well as asynchronous randomized Forward algorithms. Numerical experiments demonstrate the worth of the new algorithms that emerge from our framework.

4 - Optimal Stochastic Algorithms for Convex-Concave Saddle-Point Problems

Renbo Zhao, MIT, Cambridge, MA

We develop stochastic first-order primal-dual algorithms to solve a class of convex-concave saddle-point problems. When the saddle function is strongly convex in the primal variable, we develop the first stochastic restart scheme for this problem. When the gradient noises obey sub-Gaussian distributions, the oracle complexity of our restart scheme is strictly better than any of the existing methods, even in the deterministic case. Furthermore, for each problem parameter of interest, whenever the lower bound exists, the oracle complexity of our restart scheme is either optimal or nearly optimal (up to a log factor). The subroutine used in this scheme is itself a new stochastic algorithm developed for the problem where the saddle function is non-strongly convex in the primal variable. This new algorithm, which is based on the primal-dual hybrid gradient framework, achieves the state-of-the-art oracle complexity and may be of independent interest.

■ MC41

CC- Room 610

Linear Optimization

Contributed Session

Chair: Richard Forrester, Dickinson College, Department of Mathematics, College and Louther Street, Carlisle, PA, 17013, United States

1 - Equitable Partitions and Linear Programming

Ethan Jedidiah Deakins, University of Tennessee, Knoxville, TN, United States, edeakins@vols.utk.edu

Exploiting the symmetric structure of certain linear programming instances can offer insights into a new method for solving such instances. By means of equitable partitions, we can construct an algorithm that is a combination of both interior point and active set methods. This algorithm attempts to reduce the computational cost of crossover.

2 - On Two Dimensional Search Directions for Linear Programming

Fabio Vitor, Assistant Professor, University of Nebraska at Omaha, Omaha, NE, United States, ftorresvitor@unomaha.edu

This talk will present strategies to derive two search directions for linear programming two dimensional search algorithms. Either within the context of a simplex framework or an interior point framework, two dimensional search algorithms move between solutions by solving a two dimensional subproblem at each iteration. This subproblem is defined by the intersection of the two search directions and the feasible region of the linear program. The talk will present a comparison of the computational benefits such as a reduction in the number of iterations and solution time when different strategies are implemented to enlarge the feasible region of the two dimensional subproblem.

3 - A Strongly Polynomial-time Algorithm for Linear Programming

Hsin-Der Chen, Associate Professor, Providence University, Shalu Taichung, Taiwan

In this paper, we propose an optimization mechanism for linear programming problems. We show that linear programming problems with n variables and m general constraints in canonical form can be solved in O(m) pivoting iterations. Further specified, in the proposed algorithm we keep both an interior primal feasible point and a dual corner point in each iteration, and it runs at most 2m dual simplex steps. Therefore, the complexity of the total running time is in O(mn(m+n)).

4 - Highs: A High-performance Linear Optimizer

Julian Hall, University of Edinburgh, Edinburgh, United Kingdom, jajhall@ed.ac.uk

This talk will present HiGHS, a growing open-source repository of high-performance software for linear optimization based on award-winning computational techniques for the dual simplex method. The talk will give an insight into the work which has led to the creation of HiGHS and then set out the features which allows it to be used in a wide range of applications. Plans to extend the class of problems which can be solved using HiGHS will be set out.

5 - On the Balanced Minimum Evolution Polytope

Daniele Catanzaro, Professor of Operations Research, Université Catholique de Louvain, Louvain-la-Neuve, Belgium, Raffaele Pesenti, Laurence A. Wolsey

Recent advances on the polyhedral combinatorics of the Balanced Minimum Evolution Problem (BMEP) enabled the characterization of a number of facets of its convex hull (also referred to as the BMEP polytope) as well as the discovery of connections between this polytope and the permutoassociahedron. We extend here these studies, by presenting new results concerning some fundamental characteristics of the BMEP polytope, new facets defining inequalities in the case of six or more taxa, a number of valid inequalities, and a polynomial time oracle to recognize its vertices.

6 - Improving a Linear Formulation of the 0-1 Cubic Knapsack Problem via Variable Reordering

Richard Forrester, Professor of Mathematics, Dickinson College, Carlisle, PA, United States, forrestr@dickinson.edu, Lucas Waddell

The 0-1 cubic knapsack problem can be written in linear form using a repeated application of Glover's method for 0-1 quadratic programs. We present a simply preprocessing step to improve the strength of the linear programming relaxation based upon a variable reordering strategy. Extensive computational tests demonstrate the effectiveness of this technique.

■ MC42

CC- Room 611

Cluster Detection in Networks

Sponsored: Optimization/Network Optimization

Sponsored Session

Chair: Mohammad Hosseinian

1 - Detecting K-plexes in Sparse Graphs

Mohammad Javad Naderi, Oklahoma State University, Industrial Engineering & Manag, stillwater, OK, 74078, United States, Austin Buchanan

Finding cohesive subgroups in real-life networks (e.g., social networks) is an important task. Cohesive subgroups are often modeled as a clique, which requires a node to neighbor all other nodes in the cluster. A k-plex is a more realistic alternative that allows for a small number of nonneighbors. Existing integer programming (IP) formulations for k-plexes have a dense constraint matrix even when the input graph is sparse, making them difficult to apply directly. We craft new, equally strong IP formulations for the k-plex detection problem that use significantly fewer nonzeros, allowing them to directly handle large, sparse graphs. Experiments on real-life instances show their effectiveness.

2 - Parallel Russian Doll Search: Applications to Hereditary Structures

Mykyta Makovenko, Texas A&M University, College Station, TX, United States, Eugene Lykhovyd, Sergiy Butenko

In this work, we revisit the implementation of a general-purpose combinatorial algorithm for the maximum (weight) hereditary subgraph problem, called Russian Doll Search. The parallel shared-memory and distributed-memory versions are developed. We provide an extensive computational study for s-defective clique, s-plex, forest, chordal graph, independent union of cliques, and biclique, as the subgraphs of interest, which reveals the merit of the proposed method. For the last two structures, we present new verifiers that run in linear and constant time, respectively.

3 - Evolutionary Algorithms for the Maximum Edge Weight Clique Problem

Dalila B. M. M Fontes, INESC TEC, Universidade do Porto, INESC TEC, Rua Dr Roberto Frias, Porto, 4200-465, Portugal, dfontes@inesctec.pt, Jose Goncalves, Fernando A. C. C. Fontes

This work addresses the maximum edge weight clique problem (MEWC), an important generalization of the well-known maximum clique problem, which can be used to model applications in many. We propose a random key genetic algorithm capable of finding good quality solutions. Computational experiments on a set of benchmark problem instances show our algorithm to be both effective and efficient, as for most of the problem instances tested we were able to match the best known solutions with very small computational time requirements.

4 - Polyhedral Properties of the Induced Cluster Subgraphs

Seyedmohammadhossein Hosseinian, Texas A&M University, TX, 77843-3131, United States, hosseinian@tamu.edu, Sergiy Butenko

Given an undirected graph G, a subset of vertices inducing a cluster graph is called an Independent Union of Cliques (IUC). We study the facial structure of the IUC polytope associated with G, spot its similarities with the vertex packing and clique polytopes, and present a complete description of this polytope for certain classes of graphs. We establish computational complexity of the separation problems for the identified valid inequalities, and explore the effectiveness of employing the corresponding cutting planes in an integer (linear) programming framework for the Maximum IUC problem, which finds applications in unsupervised data analysis, through computational experiments.

■ MC43

CC- Room 612

Bayesian Optimization

Sponsored: Computing

Sponsored Session

Chair: Peter Frazier, Cornell University, Ithaca, NY, 14853, United States

1 - Bayesian Optimization of Combinatorial Structures

Matthias Poloczek, Uber AI Labs & University of Arizona, San Francisco, CA, 85721, United States, Ricardo Baptista

The optimization of expensive-to-evaluate black-box functions over combinatorial structures is an ubiquitous task in machine learning, engineering and the natural sciences. The combinatorial explosion of the search space and costly evaluations pose challenges for current techniques and critically require new algorithmic ideas. In this talk we will propose Bayesian optimization of combinatorial structures (BOCS), that takes a novel approach to overcome these challenges. We will also discuss a comprehensive experimental evaluation that demonstrate that BOCS consistently outperforms other methods from combinatorial and Bayesian optimization.

2 - Bayesian Optimization of Composite Functions

Raul Astudillo, Cornell University, Ithaca, NY, United States, Peter Frazier

We consider optimization of objective functions of the form f(x)=g(h(x)), where h is a black-box expensive-to-evaluate vector-valued function, and g is a cheap-to-evaluate real-valued function. While these problems can be solved with standard Bayesian optimization, we propose a novel approach that exploits the structure of the objective function to substantially improve sampling efficiency. Our approach models h using a multi-output Gaussian process and uses as acquisition function the expected improvement under the implied non-Gaussian posterior on f. Numerical experiments show that this approach outperforms standard Bayesian optimization benchmarks by several orders of magnitude.

3 - Knowledge Gradient with Locally Quadratic Beliefs for Policy Search

Warren B. Powell, Princeton University, Dept of Operations Research and Financial Engr, Princeton, NJ, 08544, United States, powell@princeton.edu, Nana Aboagye

A common problem is optimizing smooth functions using noisy samples without derivatives. We assume the function is smooth (ideally unimodular) but without a known parametric structure. We propose a knowledge gradient policy that maximizes the value of information using a locally quadratic belief model. The resulting policy, KGLQ, has the desirable behavior of encouraging sampling away from the current estimated optimum, but not too far away, capturing the property that the best way to learn a linear model is with observations that are far from the optimum, but not too far, since this is where the modeling errors are highest.

■ MC44

CC- Room 613

Joint Session ICS/DM: Optimization in Machine Learning I

Sponsored: Computing

Sponsored Session

Chair: John W Chinneck, Carleton University, Ottawa, ON, K1S 5B6, Canada

1 - Improving Feature Selection in Data Mining with Simulation Optimization

Kimia Vahdat, North Carolina State University, Raleigh, NC, 27695-7906, United States, kvahdat@ncsu.edu, Sara Shashaani

In many data mining applications where the number of features is large, identifying the most informative features remains a challenge. We develop a Simulation Optimization framework to search for the best subset of features with genetic algorithms. We study the effect of fixed versus variable replication size in the outcome and compare the results with some of the existing feature selection methods on a number of datasets. Investigations on computation time and overall accuracy in our preliminary results reveal that SO based approaches can provide cost-effective improvements in the predictive power of such data mining models.

2 - PAC-Bayesian Approach to Proving Risk Bounds on Neural Nets

Anirbit Mukherjee, Johns Hopkins University, Baltimore, MD, United States, amukhe14@jhu.edu, Pushpendre Rastogi, Daniel Roy, Jun Yang

Explaining deep-learning is emerging to be a fundamental mathematical challenge of our times. The core technical question is to be able to explain as to why deep learning algorithms manage to minimize the risk function while at the same time also fitting the training data arbitrarily accurately. In recent times there have been found increasing amounts of evidences that PAC-Bayesian approaches can help understand this. In this talk we will explain our new PAC-Bayesian risk bounds on nets and give experimental evidence on standard test cases for it being the state-of-the-art. (If time permits we will also present some glimpses of our recent theorems about neural net training algorithms.)

3 - Semidefinite Optimization with Hyperspherical Constraints for Metric Learning Between Sets

Abhinav Maurya, Carnegie Mellon University, Pittsburgh, PA, United States, ahmaurya@cmu.edu

We present an approach for learning a distance metric between sets based on semidefinite optimization with hyperspherical constraints. We find that this approach leads to a very efficient learning procedure called the conditional mixing method. We demonstrate its superiority compared to the dominant approach of (minibatch) gradient descent commonly used in optimization-based machine learning.

4 - Post-Separation Classifier Feature Reduction

John W. Chinneck, Carleton University, Systems and Computer Engineering, Ottawa, ON, K1S 5B6, Canada, chinneck@sce.carleton.ca

Feature reduction seeks the smallest set of features that allows acceptable separation of the data. A new approach: (i) find a separating hyperplane by any method, using all features, then (ii) find a new hyperplane giving the same separation using fewer features. The correctly classified points from the first step are used to construct a feasible LP by transforming each retained point into a linear inequality in variables representing the feature weights. A new heuristic for finding sparse solutions to LPs is then applied. The heuristic is derived from methods for solving the maximum feasible subsystem problem (maxFS).

■ MC45

CC- Room 614

First-order Methods for Saddle Point Problems

Sponsored: Optimization/Nonlinear Programming

Sponsored Session

Chair: Necdet Serhat Aybat, University Park, PA, 16802, United States

1 - Oracle Complexity of a Trust Region Method for Non-Convex Min-Max Problem

Hassan Rafique, University of Iowa, Iowa City, IA, United States, Qihang Lin

We consider minimizing the maximum of finitely many non-convex, twice continuously differentiable functions. This type of min-max problems has applications in portfolio optimization and robust machine learning. We propose a trust region method based on a QCQP oracle and analyze the number of calls to that oracle for the trust region method to find a second-order stationary point of the min-max problem.

2 - Lower Complexity Bounds of First-order Methods for Bilinear Saddle-point Problems

Yangyang Xu, Assistant Professor, Rensselaer Polytechnic Institute, Department of Mathematical Sciences, Troy, NY, 12118, United States, xuy21@rpi.edu, Yuyuan Ouyang

On a convex-concave bilinear saddle-point problem (SPP), many works have studied the complexity results of first-order methods (FOMs). They are all about upper complexity bounds, which can determine how many efforts to guarantee a solution of desired accuracy. In this talk, I will show lower complexity bounds of FOMs on large-scale SPPs. For convex-concave SPP, the lower bound is $O(1/\epsilon)$ to obtain an ϵ-solution, and when the primal objective is strongly convex and the dual objective is concave, it would be $O(1/\sqrt{\epsilon})$. Both results match with existing upper complexity bounds. Hence, the established bounds are tight and indicate the optimality of existing FOMs.

3 - A Primal-Dual Parallel Method with 1/T Convergence for Constrained Composite Convex Programs

Michael Neely, University of Southern California, CA, United States

Please check the mobile app for this abstract.

4 - Iteration Complexity of Randomized Primal-dual Methods for Stochastic Convex-concave Saddle Point Problems

Erfan Yazdandoost Hamedani, Pennsylvania State University, University Park, PA, 16801, United States, evy5047@psu.edu, Afrooz Jalilzadeh, Necdet Serhat Aybat, Uday Shanbhag

In this paper, we propose a class of randomized primal-dual methods to contend with stochastic saddle point problem of minimizing over a large-scale primal variable and maximizing over a dual variable of a convex-concave function. We analyze the convergence rate of the proposed method under the settings of mere convexity and strong convexity in primal variable. In particular, under some Lipschitz assumptions of gradients, the ergodic sequence generated by the algorithm achieves the O(1/k) convergence rate in a suitable error metric.

Furthermore, assuming a uniformly strong convexity of primal variable, and linearity in dual variable, the scheme displays convergence rate of O(1/k2).

■ MC46

CC- Room 615

Routing Under Uncertainty and with Real-time Information

Sponsored: Transportation Science & Logistics/Intelligent Transportation Systems (ITS)

Sponsored Session

Chair: Venktesh Pandey, University of Texas-Austin, Austin, TX, 78712, United States

1 - A Holistic Approach to understand Traveler Route Choice Behavior and Satisfaction under Real-time Travel Information Provision

Dong Yoon Song, Purdue University, West Lafayette, IN, United States, song50@purdue.edu, Srinivas Peeta

This study proposes a comprehensive framework to understand the key factors influencing traveler's route choice behavior and satisfaction with travel experience under real-time travel information provision. It analyzes the roles of travel time savings and psychological gains. A structural equation model is estimated to capture latent variables for human factors in information perception and multiple psychological dimensions of information provision. Data for traveler behavior and information perception are collected through interactive driving simulator experiments and the associated surveys.

2 - Risk Evaluation for Route Guidance under Recurrent and Randomized Sensing Attacks

Li Jin, New York University, Brooklyn, NY, United States, Qian Xie

This research studies the security risk of real-time route guidance. We consider a dynamic flow network with feedback routing. We formulate a sequential game between attackers and a defender, where attackers recurrently compromise sensors and/or inject malicious data at random times and random locations, and the defender allocates security resources. We will characterize the equilibrium strategies of the attackers and the defender and estimate the security risk under various attacking and defending capabilities.

3 - Adaptive Park-and-Ride Choice on Time-Dependent Stochastic Multimodal Transportation Network

Pramesh Kumar, University of Minnesota, Minneapolis, MN, 55414, United States, Alireza Khani

This research proposes a model describing the adaptive behavior of commuters who opt for park-and-ride when going from low-density areas to a high-density area depending upon the realized state of the traffic. The problem is formulated as a stochastic shortest path problem. The objective is to find a path which minimizes the expected cost between an origin and destination.

4 - Sensitivity Analysis for User Equilibrium Models with Recourse

Venktesh Pandey, University of Texas-Austin, Austin, TX, 78712, United States, Tarun Rambha, Stephen Boyles

Static user equilibrium with recourse (UER) models are used for predicting the long-term traffic behavior on networks with supply-side uncertainty where a traveler may change their route in real-time based on the information received at a node. In this research, we conduct a sensitivity analysis of UER models where we calculate the derivatives of expected travel time between two nodes, with respect to the demand between them, assuming that the flow distributes in a way that the equilibrium is maintained. This sensitivity analysis is then used for network contraction of acyclic managed lane networks with toll and travel time uncertainty.

■ MC47

CC- Room 616

TSL Air/AAS: Drones in Logistics

Sponsored: Transportation Science & Logistics/Air

Sponsored Session

Chair: Haitao Li, Univ. of Missouri-St Louis, St Louis, MO, 63121-4400, United States

1 - Economic and Environmental Impacts of Drone Delivery

Juan Zhang, University of Missour-St. Louis, St. Louis, MO, United States, jzmq3@mail.umsl.edu, James F. Campbell, Donald Sweeney

Using drones for last-mile/home delivery may reduce costs and lower emissions. In this presentation, we focus on assessing the cost and emissions tradeoffs in drone delivery from a strategic perspective. We develop and optimize continuous approximation models for expected costs and greenhouse gas (GHG) emissions. We compare the costs and GHG emissions of drone-only, hybrid truck-drone and truck-only systems under various operational conditions. We show how the cost-efficiency and environmental-friendliness of drone delivery depends on the relative operational parameters and the carbon intensity of fuels.

2 - Drone Delivery in Global Healthcare: Optimizing the Vaccine Supply Chain

Deng Pan, University of Missouri - St. Louis, St. Louis, MO, United States, dpkq8@mail.umsl.edu, Haitao Li, James F. Campbell, Donald C. Sweeney

We present two models for optimizing a hierarchical vaccine delivery network for children in less developed regions, with application to the Republic of Vanuatu. The first model, for nation-wide distribution, optimizes the use of long-range drones in a multi-modal distribution system serving 60 islands. The second model optimizes local vaccine deliveries within a single health zone (often several neighboring islands) using shorter range drones, with synchronization of drone deliveries and healthcare worker routes. Both problems require maintaining the vaccine cold chain. Preliminary results show that drones can offer important savings and improve vaccine availability.

3 - A Framework to Transform Truck-and-Drone Coordination Problems into Traveling Salesman Problems

Stefan Poikonen, University of Colorado Denver, Denver, CO, 80202, United States, Adriano Masone, Bruce L. Golden

We show that a broad range of truck-and-drone coordination problems may first be recast as an equality generalized TSP (E-GTSP) and subsequently as an asymmetric traveling salesman problem (ATSP), where the number of nodes in the ATSP is equal to the number of non-dominated operations. We then leverage the capabilities of exact or heuristic TSP solvers to solve the ATSP. Whenever we solve the ATSP exactly, we can extract an optimal solution to the original truck-and-drone coordination problem. We also extend this transformation framework to multi-truck variants. Computational experiments will be presented.

4 - Mission Planning for UAVs

Liu Yang, Assistant Professor of Supply Chain Management, Purdue University, New Albany, IN, 47150, United States, lyang@purdue.edu, Haitao Li

We consider a group of heterogeneous UAVs to be assigned and scheduled to accomplish multiple military missions. UAVs have varying capacities and must take off from and return to the same launch and recovery stations (LRS), and be controlled by ground control stations (GCS) during flight. Missions have different weapon load requirements with specific time windows and generalized precedence relationships with minimum time lags. Missions accomplished by different UAVs lead to different rewards. A mixed-integer programming (MIP) approached is developed to maximize the total rewards.

■ MC48

CC- Room 617

Healthcare Payment and Incentives

Sponsored: Manufacturing & Service Oper. Mgmt/Healthcare Operations

Sponsored Session

Chair: Elodie Adida, University of California-Riverside, Riverside, CA, 92521, United States

1 - Too Much? Too Little? Economic Modeling of Physician Testing Decisions

Tinglong Dai, Johns Hopkins University, Baltimore, MD, 21202, United States, dai@jhu.edu

Few issues in the healthcare ecosystem are more salient than the utilization of medical tests. By some estimates, up to 30% of medical-testing decisions are deemed inappropriate, which may entail either over- or under-testing. All too frequently, the public attention has centered on over-testing. By comparison, under-testing has received little media coverage, but frequently appears in the medical literature. In addition, contrary to popular belief, the US trails most OECD countries in terms of the utilization of medical tests.In this talk, I discuss several recent modeling efforts aimed at understanding physician decision-making leading to over- and under-testing.

2 - Yardstick Competition, Credence Goods, and the Design of Diagnosis Related Groups

Nicos Savva, London Business School, Regent's Park, London, NW1 4SA, United Kingdom, Laurens Debo, Robert Shumsky, Nicos Savva

Hospitals throughout the developed world are reimbursed on the basis of diagnosis related groups (DRGs), a patient classification system first developed at the Operations Research department of Yale University. Under this scheme, the hospital receives a fixed fee per patient episode that is set based on yardstick competition (the fee is set to the average cost of providing care to similar patients in other hospitals). In this paper, we show that this payment system may give rise to incentives to "cherry pick" and/or "upcode" patients, and examine potential solutions to this problem involving yardstick competition based on output statistics.

3 - Outcomes-based Reimbursement Policies for Chronic Care Pathways

Sasa Zorc, Assistant Professor, University of Virginia, Darden School of Business, Charlottesville, VA, 22903, United States, Stephen E. Chick, Sameer Hasija

We develop an outcomes-based model of contracting in care for chronic patients, using data from United Kingdom's NHS. The government contracts with healthcare providers in effort to maximise population health minus the cost. We consider the decision of whether to contract with individual healthcare providers or groups of such providers, as well as which contract type to use. Individual contracts fail to provide the desired incentives if providers under such contracts cooperate (collusion), however so do group contracts if group members fail to coordinate (free-riding). We demonstrate that individual outcomes-adjusted capitation contracts are the most resistant to these adverse effects.

4 - Outcome-based Pricing for New Pharmaceuticals via Rebates

Elodie Adida, University of California - Riverside, School of Business Administration, Riverside, CA, 92521, United States, elodie.goodman@ucr.edu

We study the effect of outcome-based pricing for new pharmaceuticals via rebates. Under this payment scheme, the pharmaceutical firm is paid only when the drug treatment achieves a pre-specified goal. We consider heterogenous, price-sensitive, risk-averse patients, a payer, and a pharmaceutical firm producing a drug with uncertain effectiveness. We find that outcome-based pricing is unlikely to solve the issues of high drug prices and high payer expenditures. However, supplementing outcome-based pricing with a transfer payment between firm and payer can make patients, payer and firm better off than under uniform pricing.

■ MC49

CC- Room 618

Joint Session TSL/Urb/Practice Curated: Renewable-energy Driven Mobility: Infrastructure Design and Management Strategies

Sponsored: Transportation Science & Logistics/Urban Transportation

Sponsored Session

Chair: Leila Hajibabai, North Carolina State University, Raleigh, NC, United States

1 - Static and Dynamic Approaches to Modeling Electric Vehicle Use and Charging Behavior

Yanbo Ge, National Renewable Energy Laboratory, Golden, CO, United States, Don MacKenzie

We compare two approaches to modeling drivers' decisions about whether to use their battery electric vehicle (BEV) or an alternative vehicle for a long-distance trip, and when and where to charge their BEV: a traditional static discrete choice model that treats all decisions as independent; and a dynamic discrete choice model that is more behaviorally realistic, but also more computationally intensive.

2 - Self-rebalancing Electrical Vehicle Sharing Management

Wang Xin, University of Wisconsin-Madison, Madison, WI, United States, Yuguang Wu

We investigate a dynamic fleet management problem (DFLP) for an electric vehicle (EV) sharing system who faces time varying random demand and electricity price. Demand in each time period reacts to the announced price. To maximize the revenue, the EV fleet optimizes operations, charging decisions as well as the pricing decisions. We use a value function approximation with convex neural networks to generate near-optimal solutions. Base on the structure of DFLP, we propose multiple improvements in the design and the training of NN. We compare it with standard ADP methods and develop insights regarding the interaction between the EV fleet and the power grid.

3 - Infrastructure Design and Dynamic Pricing of Electric Vehicle Charging Facilities with User-equilibrium Behavior

Leila Hajibabai, North Carolina State University, Department of Civil Engineering, Raleigh, NC, 11794, United States, lhajiba@ncsu.edu, Amir Mirheli

This research develops a bi-level mathematical program with EV charging facility design and demand-driven pricing scheme in the upper level and user decisions considering electricity pricing and travel time in the lower level. The model is converted into an equivalent single-level formulation using Karush-Kuhn-Tucker conditions. A hybrid technique is developed that (i) determines strategic decisions on EV charging facility design using an iterative active-set based method, (ii) establishes a relationship between occupancy and capacity of each facility using a stochastic queuing theory, and (iii) estimates arc travel times using a macroscopic fundamental diagram concept.

4 - Viability of Electric Taxis: Impact on Charging Infrastructure and Competition with Non-electric Taxis in New York City

Jae Young Jung, Ford Motor Company, Dearborn, MI, 48120, United States, jjung22@ford.com, Joseph Y. J. Chow

Electrification of taxi fleets would be a major investment to reduce CO2 emission for cities and regions. However, due to the limited driving range of electric vehicles, there is a need to better understand the fleet operation efficiency and the impact on charging infrastructure. This study conducts simulation experiments to evaluate electric vehicle taxi operation and investigate impacts on charging infrastructure in New York City. The result reveals potential revenue competition between electric and non-electric vehicles and addresses resources allocation trade-offs in subsidizing electric vehicle taxis and investing in electric charging infrastructure.

■ MC50

CC- Room 619

Spatial Analysis in Transportation and Logistics

Sponsored: Transportation Science & Logistics/Facility Logistics

Sponsored Session

Chair: EunSu Lee, New Jersey City University, Jersey City, NJ, 07311, United States

1 - Spatial Modeling for Backup Service Coverage of Rural Emergency Medical Service

EunSu Lee, Associate Professor, New Jersey City University, Jersey City, NJ, 07311, United States, elee3@njcu.edu, Melanie McDonald

This study visualizes the statewide service coverage of Emergency Medical Service (EMS) in rural areas and discusses the backup coverage using multiple service levels and various response time in study areas.

2 - Location Prediction Using Recurrent Neural Network

Ali Rahim-Taleqani, Doctoral Student, North Dakota State University, Fargo, ND, 58305, United States

Spatial and temporal contextual information plays a vital role in analyzing shared mobility user behaviors and helps predict the next visiting locations. Given the increasing volume of data from dockless scooter/bike programs, the more spatiotemporal information is collected in systems, the harder the location prediction problem becomes. Recurrent Neural Networks (RNN) model shows promising performance. Hence we proposed a novel RNN model considering the spatial and temporal scooter/bike data. Experimental results show that the proposed model yields significant improvements over similar methods.

3 - Spatio-temporal Analyzes of Traffic Accidents Using ArcGIS

Poyraz Kayabas, Purdue University, Fort Wayne, IN, 06517, United States

In this study a spatio-temporal model is developed to understand how location and time characteristics influence the likelihood of motor vehicle crashes. Creating a space-time cube, finding temporal trends, and the limitations of the study will be discussed.

4 - Spatial Analysis in the Decision Making of CEP Crowd-sourced Last-mile Delivery

Mingwei Guo, Doctoral Student, North Dakota State University, Fargo, ND, United States, mingwei.guo@ndsu.edu

With the recent soaring of the sales from E-commerce and other last-mile delivert needs, increased number of packages have put pressure on traditional delivery modes. Crowd-Sourced Last-Mile Delivery can be served as an efficient role in the development of Carrier, Express and Parcel (CEP) services. Utilizing citizen workers as part of the scenario, crowd-sourced delivery would bring potential impacts to the location selection of warehouses and package hubs. This research will utilize spatial analysis tools to look into cases of CEP last-mile needs and provide reference for further study.

■ MC51

CC- Room 620

Joint Session AAS/TSL Air: Air Traffic Management Initiatives

Sponsored: Aviation Applications

Sponsored Session

Chair: Alexander Stewart Estes, University of Minnesota, Minneapolis, MN, 55414, United States

1 - Slot Allocation: Algorithms and Implementation at Guarulhos Airport

Nuno Antunes Ribeiro, Singapore University of Technology and Design, Portugal, Singapore, Singapore, nuno_r_@hotmail.com, Diana Jorge, Alexandre Jacquillat, António Pais Antunes, Amedeo R. Odoni

Airport slot allocation involves finding flight schedules that minimize displacement from airline requests, while complying with the Worldwide Slot Guidelines. This talk outlines three recent advances. First, we develop an algorithm based on large-scale neighborhood search to optimize slot allocation at the busiest airports. Second, we perform extensive comparisons with existing practices based on real-world data. Third, we report results from an implementation in support of coordination practices in real time at Guarulhos in Sao Paulo— the busiest airport in Latin America.

2 - Airline-Driven Ground Delay Programs

Chiwei Yan, Uber Technologies, San Francisco, CA, 94103, United States and University of Washington, Seattle, WA, United States, Prem Swaroop, Michael O. Ball, Cynthia Barnhart, Vikrant Vaze

We propose an airline-driven decentralized approach for designing ground delay programs (GDPs). The motivation for an airline-driven approach is the ability to incorporate the inherent differences between airlines when prioritizing, and responding to, different GDP designs. We design a mechanism based on a voting theory called Majority Judgment and assess its benefits over centralized approaches.

3 - Relative Trajectory Cost Prediction for Applications in Collaborative Trajectory Options Program

Ivan Tereshchenko, University of California-Berkeley, Berkeley, CA, 94709, United States, terivan2006@berkeley.edu

Increasing air traffic volume makes en route Traffic Management Initiatives (TMIs) more important than ever before. The effective execution of en route TMIs depends on accurate predictions of airspace demand. Precise forecasts of airspace demand require causal models of route choice. Previous research shows that obtaining such models is difficult, due to the complex nature of the airspace system. In this paper, we propose two methods for demand prediction in the context of Collaborative Trajectory Options Program (CTOP). The testing was done using simulated CTOP data. We show that CTOP offers data structures that allow us to achieve higher quality airspace demand predictions.

4 - Alternative Resource Allocation Mechanisms for the Collaborative Trajectory Options Program (CTOP)

Alexander Stewart Estes, University of Minnesota, Minneapolis, MN, 55414, United States, este0100@umn.edu, Michael O. Ball

We identify two weaknesses in the design of the collaborative trajectory options program (CTOP) traffic management initiative. First, CTOP may issue excessive quantities of delay even when the parameters of the program are chosen correctly. Second, CTOP's current design can discourage airlines from accurately disclosing trajectory options. We propose new mechanisms that address these design flaws. We also provide computational results that demonstrate that our proposed mechanisms would reduce delay costs and encourage greater participation in CTOP.

■ MC52

CC- Skagit 1

Revenue Management & Pricing Student Paper Prize II

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Stefanus Jasin, University of Michigan, Ann Arbor, MI

1 - Sequential Procurement with Contractual and Experimental Learning

Gregory Macnamara, Stanford University Graduate School of Business, Stanford, CA

We study the design of sequential procurement strategies that integrate stochastic and strategic information.

2 - The Value of Price Discrimination in Large Random Networks

Jiali Huang, University of Minnesota, Minneapolis, MN, 55414, United States

We find, surprisingly, that the value of price discrimination in very large random networks are often not significant.

3 - Decision Forest: A Nonparametric Approach to Modeling Irrational Choice

Yi-Chun Chen, UCLA, Los Angeles, CA

We study a new nonparametric choice model that can model a wider range of customer behavior, such as decoy effects between products.

■ MC53

CC- Skagit 2

Interaction of Social Media with Revenue Management & Pricing

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Pelin Pekgun, University of South Carolina, Columbia, SC, 29205, United States

Chair: Sanghoon Cho, Columbia, SC, 29206, United States

1 - Discrete-choice Model for The Hotel Room Demand by Heterogeneous Guests

Sanghoon Cho, University of South Carolina, Columbia, SC, 29206, United States, Sanghoon.Cho@grad.moore.sc.edu, Andrew Vakhutinsky, Pelin Pekgun, Mark Ferguson

We develop a new approach to model the demand for the hotel rooms based on the individual booking attributes of each hotel guest as a combination of multiple multinomial logit models, which involves soft clustering of the guests followed by building a discrete choice model for each cluster. The demand model parameters are estimated using the EM algorithm. We demonstrate our model performance on the booking data from a medium-size hotel chain and show how varying the price for each room category affects the total revenue.

2 - How Important is Design for the Automotive Value Chain?

Hallie Cho, INSEAD, Singapore, 138676, Singapore, Manuel Sosa, Sameer Hasija

By using online customer ratings, this paper disentangles the role of different dimensions of perceived product quality in influencing consumer choice in the context of the U.S. automobile industry. We use a structural estimation model with endogenous prices and heterogeneous customer preferences to show that design is the most salient factor of perceived product quality in determining an automobile's market share. Our results have important implications for an automobile manufacturer's internal resource allocation strategy. We also highlight the changing role of on-line product review forums in the automobile industry's value chain.

3 - The Effects of Social Learning on Product Assortment and Pricing Strategy

Sanghoon Cho, University of South Carolina, Columbia, SC, 29206, United States, Pelin Pekgun, Michael Galbreth

To alleviate the uncertainty of new experience products, consumers in later purchase periods can combine user review into their decision process. Such social learning not only allows customers to gradually learn about the quality of the new experience products but also enables firms to dynamically change their optimal policy. We consider a monopolist that sells two vertically quality differentiated products over two periods to consumers who are Bayesian social learners. In the presence of two types of user reviews for both products, consumers decide on which products to purchase to maximize their utility.

4 - E-word of Mouth (WoM) on Action: Analysis of Operational Decisions in Online Retail

Bahar Cavdar, Middle East Technical University, Universiteler Mah, Dumlupinar Bulv, Ankara, 06800, Turkey, bcavdar@metu.edu.tr, Nesim K. Erkip

In this study, we consider an online shopping system with both premium and regular customers. We model customer preferences based on the perceived service quality indicated by WoM and integrate this into the retailer's operational problem to determine a shipment policy. We show that (i) beating the competition in market may not always benefit the company as it can result in undesired customer switching behavior, (ii) relaxations in operational constraints may hurt profitability due to the associated difficulties of perception management, and (iii) seeking a stationary policy can lead to suboptimal solutions, therefore cyclic policies should also be considered when appropriate.

■ MC54

CC- Skagit 3

Networks, Mechanism Design, and New Markets — II

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Ozan Candogan, University of Chicago, Chicago, IL, 27708, United States

1 - Homophily is (Not) Bad for Learning

Mohamed Mostagir, University of Michigan, Ann Arbor, MI, 48109, United States, James Siderius

The common view in the social learning literature is that homophily is not conducive to learning. We investigate this claim using a random network formation model. Agents in a population try to learn a state of the world (like for example, whether a product if of high or low quality) and a firm tries to manipulate the learning process towards a particular outcome. We show that the presence of homophily —generally a negative force when it comes to social learning— can sometimes shield a population from being manipulated, making agents overcome the attempts of distortion by the principal and instead leading them to learning the true state of the world.

2 - Shapley Meets Uniform: An Axiomatic Framework for Attribution in Online Advertising

Raghav Singal, Columbia University, New York, NY, United States, rs3566@columbia.edu, Omar Besbes, Antoine Desir, Vineet Goyal, Garud N. Iyengar

A central challenge in online advertising is attribution, namely, assessing the contribution of individual ads to product purchase. We develop an axiomatic framework for attribution in online advertising. Under a Markovian model for user behavior, we illustrate limitations of existing heuristics and propose a novel framework motivated by causality and game theory. Furthermore, we establish that our framework coincides with an adjusted ``unique-uniform" attribution scheme. This scheme is efficiently implementable and can be interpreted as a correction to the commonly used uniform attribution scheme. We supplement our theory with numerical experiments inspired by a real-world dataset.

3 - Optimal Data Acquisition for Statistical Estimation

Juba Ziani, Caltech, Pasadena, CA, 91106, United States, jziani@seas.upenn.edu, Yiling Chen, Nicole Immorlica, Brendan Lucier, Vasilis Syrgkanis

We consider a data analyst's problem of purchasing data from strategic agents to compute an unbiased estimate of a statistic of interest. Agents incur private costs to reveal their data and the costs can be arbitrarily correlated with their data. We design an IR and IC mechanism that optimizes the worst-case mean-squared error of the estimation, where the worst-case is over the unknown correlation between costs and data, subject to a budget constraint. We characterize the optimal mechanism in closed-form. We further extend our results to regression analysis, when private costs can correlate with the values of the dependent variable but not with the values of the independent variables.

4 - LP-based Approximation for Personalized Reserve Prices

Mahsa Derakhshan, University of Maryland, College Park, MD, United States, mahsa@cs.umd.edu, Negin Golrezaei, Renato Paes Leme

We study the problem of computing personalized reserve prices in eager second price auctions without having any assumption on valuation distributions. Here, the input is a dataset that contains the submitted bids of n buyers in a set of auctions, and the goal is to return personalized reserve prices r that maximize the revenue earned on these auctions by running eager second price auctions with reserve r. We present a novel LP formulation to this problem and a rounding procedure which achieves a 0.684-approximation. This improves over the 0.5-approximation algorithm due to Roughgarden and Wang. We further bound the integrality gap of the LP, which bounds the performance of any algorithm based on this LP.

■ MC55

CC- Skagit 4

Recent Topics in Revenue Management

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Victor Araman, American University of Beirut, American University of Beirut, Beirut, 1107-2020, Lebanon

Co-Chair: Dragos Florin Ciocan, INSEAD, Fontainebleau, France

1 - Using Distributionally Robust Optimization to Sharpen Mixed Integer Programming Formulations for Trained Neural Networks

Will Ma, Columbia University, New York, NY, United States, Ross Michael Anderson, Joseph Huchette, Christian Tjandraatmadja, Juan Pablo Vielma

We consider the fundamental problem of given a trained Neural Network NN, finding the input vector x within some domain D which maximizes the output NN(x). We attack this problem using Mixed-Integer Programming, and develop strong formulations for high-dimensional piecewise linear functions which represent the non-linearities in the NN. The formulations are derived using the Marginal Distribution Model from Distributionally-Robust Optimization, and shown to be sharp/ideal in various setting. We discuss many general applications of this Neural Network maximization procedure, including DNA sequencing and high-dimensional pricing.

2 - Pricing of Access Services

Ozlem Yildiz, University of Virginia, Darden School of Business, Charlottesville, VA, United States, yildizo@darden.virginia.edu, Dana G. Popescu

In access services such as shared work spaces and parking lots, the consumers pay for the privilege of accessing the firm's facilities. The service capacity is often limited and the firms typically face a mix of consumers with different needs in terms of the time they need to use those facilities as well as different willingness to pay for service. In this paper, we study different pricing strategies for access service systems. We compare the performance of a price-per-service strategy scheme to that of a price-per-unit-time scheme and give insights into the factors that might influence a firm's adoption of one pricing strategy over the other.

3 - A Logarithmic Bound for the Multi-class Dynamic Knapsack Problem

Jiawei Zhang, New York University, New York, NY, 10012, United States, Jiashuo Jiang

We consider the dynamic knapsack problem over T discrete time periods with multiple class of items. In each time period, an item arrives according to a class-dependent probability with known class-dependent reward and the weight is drawn from a class-dependent distribution function. As soon as its weight is revealed, an online decision has to be made whether or not to accept the item. The objective is to maximize the total reward collected subject to the capacity constraint. We present that an algorithm that enjoys a log(T) regret bound, which generalizes a recent result by Arlotto and Xie.

4 - Dynamic Pricing and Demand Learning with Returns

Sahar Hemmati, University of Maryland, College Park, MD, United States, Wedad Jasmine Elmaghraby, Ozge Sahin

Due to customers' uncertainty about product fit prior to purchase, retailers have been dealing with huge amount of returned products. In spite of competitive pressure for offering free returns, online retailers have the possibility to explore the demand via tools such as promotional pricing. Also, online retailers possess more flexibility in offering a variety of return policies, while banning returns over final sales or framing the non-refundable portion of paid price as shipping fee. In this paper, we are considering a seller who has limited knowledge of demand for his product and conducts dynamic pricing to learn the demand and extract as much profit as possible, considering the returns.

■ MC56

CC- Skagit 5

Analytics in Humanitarian Operations Management

Sponsored: Public Sector OR

Sponsored Session

Chair: Gloria Urrea

1 - Scalability of Follower Bases on Social Media Platforms for Humanitarian Operations

Elliot Rabinovich, Arizona State University, W. P. Carey School of Business, Department of Supply Chain Management, Tempe, AZ, 85287, United States, elliot.rabinovich@asu.edu, Eunae Yoo, Bin Gu

Humanitarian organizations aim to increase their follower bases on social media platforms to share information efficiently. Our study studies the mechanisms that drive the growth of humanitarians' follower bases. Using Twitter data from one week before and after a recent earthquake, we find that the retweeting of humanitarians' content helps to increase the organizations' number of followers. We also formulate a structural model to evaluate why users choose to follow an organization on Twitter after they have read a retweet of content by the same organization. We find that users are motivated by faster and more complete access to humanitarian organizations' content, especially after a disaster.

2 - Coopetition in First Response Operations to Global Disasters: Case of UNHRD Network

Hasti Rahemi, University of Colorado Boulder, Boulder, CO, 80303, United States, hasti.rahemi@colorado.edu, David F. Drake

We propose a coopetition model between humanitarian organizations in preparing for sudden onset disasters. While many studies show the importance of cooperation in humanitarian relief response operations, they mostly overlook the competitive nature of these operations. We implement the model on the United Nations Humanitarian Response Depot (UNHRD) that tries to incentivize cooperation among humanitarian organizations in pre-positioning stockpiles of relief supplies.

3 - Analysis of Trade Credit for Life-saving Medical Devices in Emerging Markets

Olumurejiwa Fatunde, Massachusetts Institute of Technology, Cambridge, MA, 02140, United States, Jarrod D. Goentzel

In emerging markets, health facilities often lack capital and bank financing to purchase life-saving medical devices. Distributors can increase access to essential goods through trade credit but must manage payment uncertainty to survive. We develop working capital policies to maximize the survival probability for distributors that offer trade credit for life-saving medical devices.

4 - Volunteer Management in Charity Storehouses: Experience, Congestion and Operational Performance

Gloria Urrea, University of Colorado Boulder, Boulder, CO, 47408, United States, gloria.urrea@colorado.edu, Alfonso J. Pedraza-Martinez, Maria Besiou

Volunteers are the backbone of humanitarian operations. We investigate how volunteer experience and storehouse congestion affect the preparation of orders (food and hygiene items) at a charity storehouse. Our multi-method approach begins with a field study to collect primary data on volunteers' work. Next, we estimate the effects of volunteer experience and storehouse congestion on the order processing times empirically. Finally, we simulate operational decisions—volunteers' pairing in teams and whether to allow or impede storehouse congestion—and their effect on on-time order preparation rate and additional time to prepare the orders, in steady and disaster conditions.

■ MC57

CC- Yakima 1

Joint Session PSOR/DEI: Community-Based Operations Research II

Sponsored: Public Sector OR

Sponsored Session

Chair: Michael P Johnson, University of Massachusetts-Boston, Boston, MA, 02125-3393, United States

Co-Chair: Wilkistar A. Otieno, University of Wisconsin-Milwaukee, Industrial Engineering Department, Milwaukee, WI, 53201, United States

1 - Spontaneous Emergence of Community or via Social Media

Leroy White, University of Warwick, Warwick Business School, Scarman Road, Coventry, CV4 7AL, United Kingdom, Mike Yearworth

Recently we develop a new constitutive definition of Community OR as a self-initiating, self-organising Community actor network emerging spontaneously in response to an unsettling event. We also found evidence of non-codified OR behaviours that lead to action to improve the problem situation. Here, we examine further how social media afford new possibilities for community empowerment and participation, with consequences for civil society. We draw on data arising from the community response to a devastating flooding event - the UK Carlisle floods of December 2015, and on sentiment analysis We explore the question of the OR practitioner negotiating entry to offer support.

2 - Potential Applications of Community-based Operations Research for Climate Change in the United States.

Maria Manuella Pache de Athayde, University of Massachusetts Boston, Boston, MA, 02125-3393, United States, M.PachedeAthayde001@umb.edu

Community-based operations research (CBOR) is an analytical method that is well suited to explore the interests of underrepresented communities in local settings especially when communities have limited access to the policy process. CBOR also has the potential to allow communities to make better decisions using formalized processes through the formal and informal implementation of organizational programs. This paper provides a synthesis of CBOR applications for climate change in the U.S. and proposes an application of CBOR for community resilience in urban settings.

3 - CBOR for Urban Mobility: A Social Analytics Approach to Complex Planning Issues

Tristan Stull, MS, University of Massachusetts-Boston, Boston, MA, 02125-3393, United States

In the 21st century, urban mobility is a "wicked problem" in its complexity and elusiveness of solutions. Concerns about sustainability concatenate with short-term problems of congestion, accessibility, and equity. Traditional OR has fallen short by failing to apply social theory congruently in sufficient depth and holism to drive effective optimization. The principles of community-based operations research synthesized with data science and design will inform a new kind of analytics that is both data-driven and socially complete. A well-designed approach supports both planning and public participation. This paper suggests how a CBOR-inspired solution landscape will evolve for this domain.

4 - Effective and Equitable Technology in the Digital Era

Michal Tzur, Tel Aviv University, Tel Aviv, Israel, tzur@eng.tau.ac.il, Peter Glynn, Adi Sarid

Recently there is evidence that advanced technology such as sophisticated algorithms and infrastructure planning exhibit a "discrimination" nature that can have a negative social impact. In this research, we discuss some causes for this phenomenon and present examples for its existence. Then, we suggest a general framework that includes possible remedies and ways to prevent it. Our model and framework use the notion of deprivation costs, borrowed from the literature on humanitarian logistics, as well as an equity measure based on the Gini index.

■ MC58

CC- Yakima 2

Improving Operations and Allocation Policies for Organ Transplantation

Emerging Topic: Policy & Government

Emerging Topic Session

Chair: Nikolaos Trichakis, MIT, Cambridge, MA, 02143, United States

1 - Size Based Exception Points for Fair Liver Allocation

Mustafa Akan, Associate Professor of Operations Management, Carnegie Mellon University, Pittsburgh, PA, 15213, United States, akan@cmu.edu, Musa Eren Celdir, Sridhar R. Tayur

Patients on the waiting list for liver transplants receive priority based on their Model for End-Stage Liver Disease (MELD) scores, which reflect the severity of liver disease. Recent studies have shown that for patientw with Hepatocellular Carcinoma (HCC), shorter candidates and women (which may relate to smaller stature) have longer wait times and lower probability of liver transplant. Using a queueing model and data from the Scientific Registry of Transplant Recipients (SRTR), we investigate whether additional MELD exception points would help equalize the sizebased disparity in organ access.

2 - Organ Procurement and Information Process Optimization

Paola Martin, University of Texas at Austin, Austin, TX, United States, paola.martin@mccombs.utexas.edu, Diwakar Gupta, Timothy Pruett

In the US there is a severe shortage of kidneys available for transplant. Although Organ Procurement Organizations (OPOs) receive a large number of death or imminent-death referrals from donor hospitals, the actual number of referrals that become donors is much smaller. A referral may not turn into a donor because of medical reasons, family consent or timing of the referral. In addition, there are operational and information processing related factors that may influence this outcome. The purpose of this talk is to identify all factors that affect decision-making at OPOs and develop optimization models and computer algorithms to increase the number of authorized donors and the number of transplants.

3 - Balancing Efficiency and Fairness in Liver Transplant Access: A Boundaryless Model of Organ Distribution with Implications for National Transplant Policy

Nikolaos Trichakis, MIT, Cambridge, MA, 02143, United States, ntrichakis@mit.edu, Dimitris Bertsimas, Theodore Papalexopoulos, Yuchen Wang, Ryutaro Hirose, Parsia Vagefi

Current distribution policies have resulted in persistent geographic disparity in access to donated livers for waitlisted candidates. Using mathematical optimization and simulation, the following organ distribution concepts were assessed 1) current policy, 2) proposed alternative models, and 3) a novel continuous distribution model. A number of different scenarios for each concept were generated. Continuous distribution allowed both for the greatest reduction in patient deaths and for the most equitable geographic distribution across comparable organ transportation burden.

4 - Fair Liver Transplant Allocation: A Scalable Optimization Model

Shubham Akshat, University of Maryland, College Park, MD, United States, sakshat@umd.edu, S. Raghavan, Sommer E. Gentry

U.S. Department of Health and Human Services is interested in increasing geographic equity in liver transplants. Organ supply/demand ratio can be viewed as a good proxy for evaluating access to organs by patients. We develop a nonlinear integer programming model that allocates supply in order to maximize the minimum supply/demand ratio across all transplant centers. We reformulate it as a set-partitioning problem. Our results indicate that the worst supply/demand ratio across transplant centers is improved upon significantly. Simulation studies suggest reduced geographic disparity and an annual saving of more than 70 lives (on average) compared to the current 11 region system with full sharing.

■ MC58a

CC- Chelan 1

1:30-2:15 Lindo Systems, Inc.
2:15-3:00 Gurobi Optimization

Vendor Tutorial

1 - Optimization Modeling Tools from LINDO Systems

Mark A. Wiley, LINDO Systems Inc, 1415 No Dayton Street, Chicago, IL, 60622, United States, Gautier Laude

Exceptional ease of use, wide range of capabilities, and flexibility have made LINDO software the tool of choice for thousands of Operations Research professionals across nearly every industry for over 30 years. LINDO offers solvers to cover all your optimization needs. The Linear Programming solvers handle million variable/constraint problems fast and reliably. The Quadratic/SOCP/Barrier solver efficiently handles quadratically constrained problems. The Integer solver works fast and reliably with LP, QP and NLP models. The Global NLP solver finds the guaranteed global optimum of nonconvex models. The Stochastic Programming solver has a full range of capabilities for planning under uncertainty. Get the tools you need to get up and running quickly. LINDO provides a set of intuitive interfaces to suit your modeling preference. · What's Best! is an add-in to Excel that you can use to quickly build models that managers can use and understand. · LINDO has a full featured modeling language for expressing complex models clearly and concisely, and it has links to Excel and databases that make data handling easy. · LINDO API is a callable library that allows you to seamlessly embed the solvers into your own applications. Pick the best tool for the job based upon who will build the application, who will use it, and where the data reside. Technical support at LINDO is responsive and thorough - whether you have questions about the software or need some modeling advise. Get started today. Visit our booth or www.lindo.com to get more information and pick up full capacity evaluation licenses.

2 - Improvements in the Gurobi Python Interface

Greg Glockner, Gurobi Optimization, Bellevue, WA, United States, Ed Rothberg

Our new release brings with it several significant improvements to our Python interface. We'll give you an overview of what was possible before, and what is possible now. We'll also present several examples that demonstrate the new capabilities.

■ MC59

CC- Chelan 2

Industry Job Hunting Session

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Kaibo Liu

Chair: Abdallah A Chehade, University of Michigan-Dearborn, Dearborn, MI, 48128, United States

Moderator

Abdallah Chehade, University of Michigan-Dearborn, Dearborn, MI, United States, achehade@umich.edu

The goal of this session is to help students better prepare for industry job hunting. The session provides a forum where participants can share their experience in job hunting, recruitment opportunity, industry interview process, and do's and don'ts associated with the job search.

Panelists

- Na An, Amazon, Bellevue, WA, 98006, United States
- Ji Liu
- Zuzka Bodik, Facebook, Seattle, WA, United States
- Mojtaba Khanzadeh

■ MC59a

CC- Chelan 3

Finance II

Contributed Session

Chair: Faraz Dadgostari, Charlottesville, VA, 22903, United States

1 - Limited Attention and Asymmetric Overnight Return Puzzle in Chinese Stock Markets

Fei Su, Nanjing University of Aeronautics and Astronautics, Nanjing, China, sufei@126.com

In this paper, we reinvestigate an interesting puzzle that the average overnight return on market portfolio is significantly negative in China's stock market. Furthermore, we find that the overnight return puzzle only appears on days with lagged negative daytime returns, which is termed "Asymmetric Overnight Return Puzzle". Empirical evidence reveals that the limited attention theory can at least partially explain this phenomenon, namely, investors with limited attention would response more strongly to bad news than to good news, which may lead to short-term momentum in the overnight period on days with negative information shocks.

2 - Price Discovery of Steel Commodities on the Supply Side Structural Reform Period

Wen Fang, Xidian University, Xi'an, China, az-moju@163.com

This study focuses on price discovery of steel commodities during the supply-side structural reform period. After using two different futures contracts for three kinds of steel commodities, we found that price discovery function of futures market is stronger than the spot market by applying the most active futures contracts. However, if the data of nearby contract is used, price discovery of futures is weaker than spot market in the pre-reform and post-reform study periods. By applying multivariable time-varying research model, our findings show that if we neglect closely related steel futures, we would draw to different conclusions about steel spot and futures price discovery function.

3 - Share Pledge Transactions, Investor Sentiment and Volatility

Hengzhen Lu, Nanjing University of Aeronautics and Astronautics, Nanjing, China, Luhengzhen@nuaa.edu.cn

This paper examines how share pledge transactions affect stock price volatility. We developed an investor overconfidence model about the impact of share pledge transaction on stock price. We find that share pledge trading can lead to emotional bias and consequently affect investment decisions. We studied the relationship between investor sentiment indicators including share pledges transaction factors and stock price volatility. We find that the impact of share pledge trading on investor sentiment has a positive impact in the long term. It shows that pledge trading does have accelerating effect on stock price cyclical fluctuation through investor sentiment effect.

4 - Modeling and Measuring Systemic Risk

Faraz Dadgostari, University of Virginia, Charlottesville, VA, United States, fd4cd@virginia.edu, Peter A. Beling

We propose a novel mathematical framework to model financial markets as complex systems of economic interactions and contractual and legal obligations aiming to understand, measure and mitigate systemic risk exposure of economy from the perspective of the policymakers and regulators. The proposed mechanism exploits the systemic structure of contractual dependencies of the financial institutions in a competitive market where banks maximize their individual share of the financial market/profit. The resulting framework would be ideal for developing alternative regulatory technologies to mitigate aggregate systemic risk exposure of the economy, subject to minimum intervention.

■ MC60

CC- Chelan 4

QSR International Activities I: QSR Research in Asia

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Nan Chen, National University of Singapore, 117576, Singapore

Co-Chair: Xi Zhang, Peking University, Beijing, 100871, China

Co-Chair: Chen Zhang, Tsinghua University, Singapore, 117576, Singapore

Co-Chair: Xiao Liu

1 – QSR Research and Funding Opportunities in Singapore

Nan Chen, National University of Singapore, Department of Industrial and System Eng, 1 Engineering Drive 2, Singapore, 117576, Singapore

In this presentation, we will briefly introduce some funding schemes and opportunities, especially for international collaborations in the research areas related to QSR. We will also introduce some major research initiatives and undergoing research projects to explore possible collaborations.

2 - Online Monitoring of Pipeline Corrosion Process via Machine Learning Methodsonline Monitoring of Pipeline Corrosion Process via Machine Learning Methods

Chen Zhang, Assistant Professor, Tsinghua University, e1-07-26, 3 Engineering Drive, beijing, 117576, China, zhangchen01@tsinghua.edu.cn

We present an online monitoring algorithm for tube wall corrosion process based on FBG sensors. We first develop a spatio-temporal model for FBG signal extraction. The model can remove environmental influence and extract FBG features that relate to tube thickness. Then model residuals can be regarded as features caused by sensors' own properties, such as its local thickness and local system vibrations. Consequentially, we can use the regression residuals for thickness feature extraction. Then taking the physical principle as guideline, we construct a nonlinear model to describe the relationship between residual feature and the tube thickness and use the relationship for online monitoring.

3 - Some Research Collaboration Opportunities in Data Analytics in Mainland China

Xi Zhang, Peking University, Beijing, China, xi.zhang@pku.edu.cn, Jianguo Wu

In recent years, some interesting opportunities have emerged for the development of engineering data analytics and associated disciplines, with the growth of IT technologies in China. In this talk, the speaker would like to review some previous and ongoing projects related to engineering data analytics, and also would share some thoughts regarding the future directions.

■ MC61

CC- Chelan 5

Industrial Data Analytics

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Heeyoung Kim, Korea Advanced Institute of Science and Technology, Daejon, Korea, Republic of

1 - Repeatedly Estimating Correlated and Normally Distributed Parameters of an Expensive and Highly Nonlinear Model

Chuljin Park, Hanyang University, KAIST ISYSE, Yuseong-gu, Seoul, Korea, Republic of, chuljini@gmail.com

We consider a problem of repeatedly estimating parameter vectors of a highly nonlinear and expensive model, where the parameter vectors of the model are sampled from a multivariate normal distribution. The mean vector and covariance matrix of the parameter distribution are assumed to be pre-known or can be estimated. We propose a new framework, called the distribution-guided heuristic search, which can be combined with any heuristic algorithm to solve the target problem. The framework was tested in simulation studies and was applied to measuring the critical dimensions of a 2-D high aspect ratio structure of a wafer in semiconductor manufacturing.

2 - Maximum Feasibility Estimation

Sungil Kim, Ulsan, 44919, Korea, Republic of, sungil.kim@unist.ac.kr

This paper proposes a novel parameter estimation method called the maximum feasibility estimation(MFE). The MFE does not rely on any assumption about parametric family of probability densities from which a random observation is drawn. Instead, we assume that constraints are imposed on observations and some of constraints are a function of a parameter of interest. The proposed estimator maximizes the feasible region, a set of all possible observations that satisfy those constraints. The method proposed is validated by using synthetic data as well as real streaming event log data.

3 - Statistical Modeling and Analysis of K-layer Coverage of Two-dimensional Materials in Inkjet Printing Processes

Jaesung Lee, University of Wisconsin-Madison, Madison, WI, United States, lee826@wisc.edu, Shiyu Zhou, Junhong Chen

Two-dimensional(2D) materials have been receiving great attention in electronics fabrication due to their intriguing properties. The k-layer coverage area of printed flake pattern significantly impacts on the properties of the printed electronics. We constructed a statistical model to describe the k-layer coverage of randomly distributed 2D materials, providing the expectation and variance of coverage area. An approximated statistical testing approach is also developed to detect abnormal coverage patterns. The case studies based on simulated data and real flake images obtained from the inkjet printing process show the accuracy and effectiveness of the proposed model and analysis methods.

4 - Hierarchical Bayesian Kernel Model: Prediction Using Small Data

Hiba Baroud, Vanderbilt University, Nashville, TN, 37235, United States, hiba.baroud@vanderbilt.edu, Jinzhu Yu

Various research applications suffer from small data and require highly predictive models. A major challenge in predicting the recovery rate of communities after disasters is that recovery data are often scarce due to the nature of extreme events. To address this challenge, we propose a new model called the Hierarchical Bayesian Kernel Model (HBKM). This model integrates the Bayesian property of improving predictive accuracy as data are dynamically accumulated, the kernel function that can make nonlinear data more manageable, and the hierarchical property of borrowing information from different sources in scarce and diverse data samples. Model performance is evaluated using sample data.

5 - Repeatedly Estimating Correlated and Normally Distributed Parameters of an Expensive and Highly Nonlinear Model

Chuljin Park, Hanyang University, Seoul, Korea, Republic of, chuljini@gmail.com, Hyungjin Kim

We consider a problem of repeatedly estimating parameter vectors of a highly nonlinear and expensive model, where the parameter vectors of the model are sampled from a multivariate normal distribution. The mean vector and covariance matrix of the parameter distribution are assumed to be pre-known or can be estimated. We propose a new framework, called the distribution-guided heuristic search, which can be combined with any heuristic algorithm to solve the target problem. The framework was tested in simulation studies and was applied to measuring the critical dimensions of a 2-D high aspect ratio structure of a wafer in semiconductor manufacturing.

■ MC62

CC- Tahoma 1

Data-driven Decisions in Healthcare

Sponsored: Health Applications

Sponsored Session

Chair: Vishal Ahuja, Southern Methodist University, Dallas, TX, 75275, United States

1 - Optimizing Interventions in Health Care Settings

Margret V. Bjarnadottir, University of Maryland, College Park, MD, 112, United States, margret@rhsmith.umd.edu, Weiguang Wang, Gordon Gao, Leila Zia

Risk prediction models are increasingly common in the health care system. The implementation of these models in clinical settings includes a choice of which intervention programs, if any, to offer and to which members in order to improve outcomes. We model two applications and report the results.

2 - Estimating the Attributable Cost of Physician Burnout in the United States

Shasha Han, National University of Singapore, NUS Business School, Biz 2 Building B1, 1 Business Link, Singapore, Singapore, shashahan@u.nus.edu, Tait Shanafelt, Christine Sinsky, Joel Goh

Even though physician burnout is known to be associated with negative clinical and organizational outcomes, the economic costs associated with burnout are poorly understood. Consequently, leaders in healthcare cannot properly assess the financial benefits of initiatives to remediate physician burnout. In the study, we provide a model to estimate burnout-associated costs related to physician turnover and physicians reducing their clinical hours at national (U.S.) and organizational levels.

3 - An Analytics-driven Approach for Optimal Individualized Diabetes Screening

Hossein Kamalzadeh, Southern Methodist University, Dallas, TX, 75206, United States, Michael Hahsler, Vishal Ahuja, Michael Bowen

About 10% of the US adult population has diabetes, and almost 40% are at risk of developing diabetes. Guidelines suggest population-based screening, however, in resource-restricted settings (e.g., for safety-net providers), prioritizing whom to screen and when is essential. We combine analytics methods (hidden Markov models and predictive analytics) with partially observable Markov decision process models to derive the optimal screening policy customized to the characteristics of the provider's subpopulation. We will present results for electronic health record data from the Parkland Health & Hospital System.

4 - Outcome-adaptive Iterative Elastic Net: A Tool for Causal Inference in the Observational Setting

Ashkan Farahani, UT Arlington, Arlington, TX, United States, ashkan.aliabadifarahani@mavs.uta.edu, Victoria C. P. Chen, Nilabh Ohol, Jay Michael Rosenberger

We focus on the adaptive treatment regime in the observational setting where the dynamic nature of the problem causes a bias called endogeneity or time-varying confounding. While previous studies handled one treatment case, we are focusing on the "multiple correlated treatment" case where the aim of the study is to "uncover the true underlying outcome model" at each stage. We propose the "Outcome-Adaptive Iterative Elastic Net" that augments (1) the consistent selection of true outcome-predictors, true confounders and more importantly causal "treatments". (2) adjusting for time varying-confounding by IPTW method for "multiple treatments". (3) Inclusion of the correct effect-modifiers.

■ MC63

CC- Tahoma 2

Topics in Hospital and Patient Management

Sponsored: Health Applications

Sponsored Session

Chair: Pengyi Shi, Purdue University, West Lafayette, IN, 47907, United States

1 - Platelet Inventory Sharing in a Two-hospital System

Can Zhang, Duke University, Durham, NC, 27708, United States, c.zhang@duke.edu, Turgay Ayer, Chelsea C. White

Motivated by a platelet inventory management problem in a local hospital network, we present one of the first analysis of perishable inventory sharing in a two-location system. We derive structural properties of the optimal policy and present managerial insights that significantly differ from those in existing studies for non-perishable products.

2 - Design of Incentive Programs for Optimal Medication Adherence

Joel Goh, NUS Business School, Mochtar Riady Building, Singapore, 119245, Singapore, Sze-chuan Suen, Diana M. Negoescu

We consider how to design a schedule of incentive payments to induce optimal treatment adherence levels with heterogeneous patient preferences for adherence. A unique challenge in this problem is that any prior commitment that a patient makes to a given level of treatment adherence cannot be contracted upon, rendering existing contract-theoretic approaches ineffective. We develop new models and analyses to capture this feature and conduct a numerical study using representative data in the context of the tuberculosis epidemic in India.

3 - Surgical Case-Mix and Discharge Decisions: Does Within-Hospital Coordination Matter

Vanitha Virudachalam, University of Illinois at Urbana-Champaign, Urbana-Champaign, IL, 19104, United States, vanitha@wharton.upenn.edu, Hessam Bavafa, Lerzan E. Ormeci, Sergei Savin

We study the problem faced by a hospital that controls patient inflows by designing a case-mix of elective procedures and patient outflows via patient discharges. Our model analyzes the impact of patient flow decisions on the utilization of two classes of resources, front-end (e.g. operating rooms), and backroom (e.g. recovery beds). We assess the benefit from coordinated decision-making, where portfolio and discharge decisions are made in tandem, when compared to two decentralized approaches: front-end (both decisions are made based only on front-end costs) and siloed (discharge decisions are made based on backroom costs, and the case-mix is the optimal match for the discharge policy).

4 - How to Elicit Physician Judgment to Improve Surgery Duration Prediction Algorithms

Song-Hee Kim, University of Southern California, Los Angeles, CA, 90089, United States, songheek@marshall.usc.edu, Rouba Ibrahim, Jordan D. Tong, Joan Brown

Increasingly, hospitals are trying to use algorithms to predict surgery duration times. These algorithms may use both observable data and physician judgmental forecasts. Using field data, we find that physician forecasts add significant predictive value when included in algorithms — so it is desirable to incorporate their judgment. We then study how to best elicit physician judgment when these judgments are not used directly, but rather indirectly as inputs for algorithms. Through behavioral models and controlled experiments, we conjecture and find evidence that there are better ways to elicit physician judgment than directly asking physicians for their surgery duration forecast.

■ MC64

CC- Tahoma 3

HAS Distinguished Speakers - III

Sponsored: Health Applications

Sponsored Session

Chair: Mark P. Van Oyen, University of Michigan, Ann Arbor, MI, 48109-2117, United States

Chair: Hui Zhao, The Pennsylvania State University, Smeal College of Business, University Park, PA, 16802, United States

1 - Big Data and the Precision Medicine Revolution

Wallace J. Hopp, University of Michigan, Ann Arbor, MI, 48109-1234, United States

The big data revolution is making vast amounts of information available in all sectors of the economy including health care. One important type of data that is particularly relevant to medicine is observational data from actual practice. In comparison to experimental data from clinical studies, observational data offers much larger sample sizes and much broader coverage of patient variables. However, because it is high dimensional and uncontrolled, observational data presents unique challenges. This talk will describe some recent results and some future opportunities for addressing these challenges.

2 - Perspectives on Successful Healthcare Analytics Projects

Turgay Ayer, Georgia Institute of Technology, School of Industrial and Systems Engineering, Atlanta, GA, 30332, United States, ayer@isye.gatech.edu

In this talk, I will i) provide an overview of multiple research projects on healthcare analytics, ii) present my perspectives on key ingredients of successful healthcare analytics papers/projects, and iii) discuss the potential growth of healthcare analytics within the INFORMS community.

■ MC65

CC- Tahoma 4

Application of Operations Research Models to Staffing in Healthcare System

Sponsored: Health Applications

Sponsored Session

Chair: Jacqueline Griffin, Northeastern University, Boston, MA, 02115, United States

Co-Chair: Ann Suhaimi, Northeastern University, Boston, MA, 02115, United States

1 - Effective Methods for Solving a Large-scale Resident Block Scheduling Problem with Multi-criteria Objectives

Junhong Guo, University of Michigan, 1205 Beal Avenue, Ann Arbor, MI, 48109-2117, United States, jhguo@umich.edu, Amy Cohn

Each year, program directors must construct block schedules for their residency programs. Residents submit their prioritized preferences with respect to vacation times and electives, which introduces multiple objective criteria. This problem is often formulated as an integer programming (IP) and is solved through a hierarchical procedure. However, these IPs often suffer from long run times; the generated schedule is not always satisfactory to each individual resident; and there is no guarantee of fairness across all residents. To address these issues, we propose several methods to speed up the construction process, as well as new approaches to address the multi-criteria objective function.

2 - Determining Nurse Staffing to Maximize Patient Safety and Nurse Satisfaction

Anna Svirsko, United States Naval Academy, Annapolis, MD, 15217, United States, ACS167@pitt.edu, Bryan A. Norman, Bo Zeng

In the emergency department, nurses are an important part of the team that administers care to patients. However, the nurses rely not only on the physicians in the emergency department, but also on the external services of consults, radiology, labs, and pharmacy to aid in providing care. The staffing levels of physicians and the external services can affect the nurse's ability to progress the care of the patient. In addition, emergency departments are frequently understaffed, increasing the difficulty to determine appropriate staffing levels. We use robust optimization to help determine nurse staffing levels with regards to patient safety and nurse satisfaction.

3 - Evaluating Residents and Physicians Assignment Policies in an Outpatient Dermatology Clinic using Discrete-Event Simulation

Ann Suhaimi, Northeastern University, Boston, MA, 02115, United States, nmsuhaimi@gmail.com, Jacqueline Griffin

Productivity of providers are measured differently based on the role of the provider in the clinic. For physicians, the focus is to maximize number of patients seen while for residents, it is to maximize learning objectives both when they are interacting with patients, and with physicians. We present a discrete-event simulation model based on the daily operations of a dermatology clinic located to evaluate the provider assignments and suggest new policies to maximize their productivity. Criteria such as patient waiting time, provider idleness, and clinic closing time is incorporated in the model.

4 - Optimized Planning of School Operations at Hospitals

Jens Brunner, University of Augsburg, Faculty of Business and Economics, Augsburg, 86159, Germany, jens.brunner@unikat.uni-augsburg.de, Markus Seizinger, Sebastian Kohl

The shortage of nurses is one of the most urgent problems in health services and finding well-trained nurses is a big challenge. In Germany, the vocational training system closely combines theoretical and practical education and is highly regulated by federal legislation. Nurses rotate through vocational school-blocks followed by assignments to hospital units. We develop two mixed integer programming models for this problem. The first model determines the number and length of school- and work-blocks on a class level whereas the second model finds an individual unit-assignment for every nurse. Our approach enables vocational schools to solve this complex planning problem efficiently.

5 - Integrating Standardization and Optimization Based Simulation in Staffing Model Development for Care Management

Gene Shan, University of Houston-Clear Lake, Houston, TX, United States, shan@uhcl.edu, Zhanting Gao, Silei Shan, Mohammad Khasawneh

As the population that lives in the United States ages and has longer life spans, more people are living with chronic diseases. Therefore, there is a significant demand for the efficient operations of care management organizations to support them and improve their quality of life. In this paper, we integrate process improvement with simulation-based optimization. Our results show significant improvements could be achieved with both approaches.

■ MC66

CC- Tahoma 5

Personalized Medicine II

Emerging Topic: Personalized Health

Emerging Topic Session

Chair: Jennifer Mason Lobo, University of Virginia, Charlottesville, VA, 22902, United States

Co-Chair: Hyojung Kang, University of Illinois at Urbana-Champaign, Mahomet, IL, 61853, United States

1 - Analysis of Temporal Patterns of Sepsis-related Cellular and Physiological Responses to Inform Personalized Prediction of Mortality

Muge Capan, Drexel University, Philadelphia, PA, United States, Ali Jazayeri, Christopher Yang, Min Chi, Julie Simmons Ivy, Jeanne Marie Huddleston, Ryan Arnold

Sepsis is a multi-stage health condition with high mortality rate. While sepsis-related cellular and physiological responses have been utilized as independent factors to predict outcomes, temporal dependencies between these factors are understudied. Using electronic health records data from 13,367 unique patients, we model sepsis progression developing novel co-failure networks and association rule algorithms. Key results show that proximity and frequency of cellular and physiological co-failures are sepsis stage-specific and there are significant proximate failures that play a major role in predicting in-hospital mortality in a personalized manner.

2 - Subtree Decomposition for Multistage Stochastic Integer Programs

Rahman Khorramfar, North Carolina State University, Raleigh, NC, 27606, United States, rkhorra@ncsu.edu, Osman Ozaltin

Real life instances of multistage stochastic integer programs are often solved using scenario decomposition due their extensive size. In scenario decomposition subproblems are formulated for scenario clusters. We develop a decomposition approach in which subproblems are formulated for scenario tree node clusters. This approach generalizes scenario decomposition. We present numerical experiments using well-known test problems.

3 - Dynamic Prediction of Patient Outcomes: A Deep Learning Approach

Erkin Otles, University of Michigan, Ann Arbor, MI, United States, eotles@umich.edu, Haozhu Wang, Jon Seymour, Jenna Wiens, Brian T. Denton

Physicians are awash in a sea of data. Machine learning (ML) methods could help power clinical decision support tools, however classical ML methods dictate the need for data transformations that destroy important clinical signals, such as temporality and high dimensional categories. We present a novel clinical data transformation platform paired with a recurrent neural network architecture. In tandem these methods allow for prediction of patient outcomes with respect to complex clinical information observed over time. Discussion of this approach will include results from the task of dynamically predicting patient recovery from occupational injuries.

4 - Subgrouping of Patient Trajectories for Personalized Care: Evidence from Low Back Pain

Stefan Feuerriegel, ETH Zürich, Weinbergstr., Zürich, 8092, Switzerland, sfeuerriegel@ethz.ch, Christof Naumzik

Personalizing healthcare via subgrouping promises to translate clinical data into subgroup-specific disease management that is more effective. Yet a rigorous clustering framework and a study of its cost-effectiveness is lacking. As a remedy, our work thus proposes a mixture hidden Markov model that leverages the actual illness progression for clustering. This allows us to compare costs from a one-treatment-fits-all scheme with the cost of providing subgroup-specific care. We demonstrate our subgrouping technique based on a longitudinal study across patients suffering from non-specific low back pain.

5 - Optimal Treatment Strategy for Patients with Severe Emphysema

Maryam Alimohammadi, University of Arkansas, Fayetteville, AR, United States, malimoha@email.uark.edu, Shengfan Zhang, Art Chaovalitwongse

Emphysema is a chronic lung disease that has two main treatment options: medical therapy and lung-volume reduction surgery (LVRS). This study proposes a Markov decision process model to identify the optimal treatment strategies for patients with severe emphysema, considering the cost of the treatments and quality-adjusted life expectancy of the patients. We present both the long-term and short-term results to evaluate patient outcomes under different timing for LVRS considering patients characteristics.

■ MC67

S- Virginia

Sample Average Approximation

Sponsored: Simulation

Sponsored Session

Chair: Dashi Singham, Naval Postgraduate School, Monterey, CA, 93943, United States

1 - Robust Importance Sampling for Loss Minimization under Covariate Shift

Henry Lam, Columbia University, New York, NY, 10027, United States, henry.lam@columbia.edu

In empirical loss minimization problems where only partial information is revealed from a data set and the remaining information is revealed from another set under a different distribution (a setting known as covariate shift), common approaches such as kernel mean matching rely on estimating the importance sampling weights between the two distributions, which can sometimes add substantial variance to the solution estimates. We present a scheme to reduce variance and enhance robustness in these contexts based on a systematic use of control variates. We provide theoretical bounds and demonstrate our approach in several common statistical learning tasks.

2 - Retrospective Approximation for Stochastic Optimization

David Newton, Purdue University, Department of Statistics, West Lafayette, IN, 47907, United States, newton34@purdue.edu

The Stochastic Gradient Descent (SGD) recursion is the ``workhorse" recursion for machine learning. For smooth, strongly convex objectives, the SGD recursion achieves the Cram\'{e}r-Rao lower bound when the learning rate is chosen optimally. Such choice, however, depends on unknown curvature constants, and mis-choice leads to degraded rates. There is indication that this situation is not merely ``theoretical." As a remedy, we present Retrospective Approximation (RA) —- a sequential SAA framework that facilitates embedding the best deterministic solvers, e.g., BFGS with line search, leading to excellent finite-time performance. We show when RA achieves the Cram\'{e}r-Rao lower bound.

3 - Uniform Convergence of Sample Average Approximation with Adaptive Multiple Importance Sampling

Ben Feng, University of Waterloo, Waterloo, ON, N2J 4Y3, Canada, ben.feng@uwaterloo.ca, Alvaro Maggiar, Jeremy C. Staum, Andreas Waechter

We study sample average approximations under adaptive importance sampling in which the sample densities may depend on previous random samples. Based on a generic uniform law of large numbers, we establish uniform convergence of the sample average approximation to the function being approximated. In the optimization context, we obtain convergence of the optimal value and optimal solutions of the sample average approximation.

4 - Sample Average Approximation for Univariate Functions

Dashi Singham, Naval Postgraduate School, Operations Research Department, Monterey, CA, 93943, United States, dsingham@nps.edu

Most sample average approximation methods are applied when the set of decision variables is finite. This research develops methods of finding optimal solutions to infinite-dimensional optimization problems when the decision variable is a well-defined continuous univariate function defined over the space of a random variable. We approximate the problem and apply sample average approximation to find a discrete solution, which we interpolate to approximate the continuous function.

■ MC68

S- University

Topics in Cloud Computing

Emerging Topic: Sharing Economy & Crowdsourcing

Emerging Topic Session

Chair: Ishai Menache, Microsoft, Redmond, WA, 98052, United States

Chair: Sebastian Perez Salazar

1 - Heavy-traffic Analysis of Queueing Systems with No Complete Resource Pooling

Siva Theja Maguluri, Georgia Institute of Technology, Atlanta, GA, United States, siva.theja@gatech.edu

Resource Allocation problems in Stochastic Processing Networks arise in a variety of systems. Exactly characterizing the performance of these systems is intractable and so, these systems are studied in various asymptotic regimes, such as heavy-traffic. When the so-called complete resource pooling (CRP) condition is satisfied, these systems usually have a single bottleneck resource in the heavy-traffic limit and so behave like a single queue. There are many systems such as the Input-queued switch and the bandwidth sharing system that do not satisfy the CRP, and so, their heavy-traffic behavior is not completely understood. Recent results in such systems using the Drift method will be presented.

2 - Resource Allocation in a Parallel World

Mor Harchol-Balter, Carnegie Mellon University, Computer Science Dept, Pittsburgh, PA, 15213, United States, harchol@cs.cmu.edu, Benjamin Berg, Rein A. Vesilo

Today's cloud computing workloads are typically parallel jobs which are designed to run across multiple servers. These jobs are often flexible, in that they can be run on many servers (in a short time) or on few servers (in a longer time). We are interested in the question of how to allocate servers between jobs in the case where there are several jobs and a limited total number of servers. This is a wide open problem. It is made difficult by the fact that the speedup experienced by allocating more servers to a job is often sublinear with diminishing returns. We present the first results on optimal allocation of servers to jobs for a set of jobs which all follow the same speedup function.

3 - Striking the Right Utilization-availability Balance in WAN Traffic Engineering

Ishai Menache, Microsoft Research, Redmond, WA, 98052, United States, ishai@microsoft.com

A key challenge in Wide Area Networks is striking a good balance between network utilization and availability, as these are inherently at odds; a highly utilized network might not be able to withstand unexpected traffic shifts resulting from link/node failures. We advocate a novel approach to this challenge that draws inspiration from financial risk theory: leverage empirical data to generate a probabilistic model of network failures and maximize bandwidth allocation to network users subject to an operator-specified availability target. Our approach enables network operators to strike the utilization availability balance that best suits their goals and operational reality.

4 - Dynamic Resource Allocation in the Cloud with Near-optimal Efficiency

Sebastian Perez-Salazar, Georgia Institute of Technology, Atlanta, GA, 30309, United States

A goal in cloud computing is to share a resource among users with distinct and unpredictable demands. Cloud offerings often come with a service level agreement (SLA) specifying the amount of resource a user can utilize. In many cases providers try to operate resources at high utilization while simultaneously satisfy SLA. There is a tradeoff in these 2 goals; e g, a static policy only ensuring SLA can lead to poor usage of resources. In this work we design a model that captures basic properties of cloud systems: SLA, limited feedback and arbitrary demand. We design simple algorithms that achieve near optimal utilization of a resource compared to offline dynamic solutions while satisfy SLAs up to a small error.

■ MC69

S- Seneca

SpORts Analytics III

Sponsored: SpORts

Sponsored Session

Chair: Stephen Hill, University of North Carolina-Wilmington, Wilmington, NC, 28403-5611, United States

1 - Could Have Been a Contender Factors Driving Competitiveness in the NCAA Mens Basketball Tournament

Stephen Hill, University of North Carolina-Wilmington, Wilmington, NC, 28403-5611, United States, hills@uncw.edu

In this work we discuss characteristics that may predict whether a team is competitive in the NCAA Mens Basketball tournament. This work is inspired by a Kaggle competition launched for the 2019 tournament. We begin by defining competitiveness and then applying analytical techniques to identify teams that have demonstrated competitiveness.

2 - Can Twitter Data Improve the Stock Price Predictions for Sports Clubs? Case of Turkish Soccer League

Altug Tanaltay, Sabanci University, Istanbul, Turkey, Amirreza Safari-Langroudi, Raha Akhavan-Tabatabaei, Nihat Kasap

Finance literature in sports focuses on three main methods of stock price prediction in soccer: based on match results, pre-match expectations or match importance. For pre-match expectations, betting odds is commonly used as the indicator of investors' sentiments. We propose to include Twitter data as another indicator of this variable, and analyze the links between soccer match results, sentiments, and stock returns of the four major Turkish soccer teams. Our results show that social media can be a strong indicator of pre-match expectations and investors' sentiments in stock price prediction.

3 - Team-specific Ticket Options: An Empirical Analysis of the Online Marketplace for College Football.

Ovunc Yilmaz, University of Notre Dame, Notre Dame, IN, 46617, United States, oyilmaz@nd.edu, Matthew Gartenhaus

Team-specific ticket options have recently gained popularity in the sports industry. Using a unique data set from a company selling these options, we investigate the main drivers of the option prices and transaction volumes in primary and secondary markets.

4 - Analysis of Chris Davis's Hitless Streak

Matthew Hanson, Student, University of North Carolina at Wilmington, Wilmington, NC, United States, mh7240@uncw.edu, Christian Gay

In this project we investigate the struggles of Baltimore Orioles First Baseman Chris Davis. He recently gained notoriety for setting the record for most consecutive plate appearances (for a non-pitcher) without registering a hit. We analyze other hitless streaks in his career, his performance over his career, and commonalities among players who have also experienced long hitless streaks.

■ MC70

S- Jefferson A

Theories and Applications of Interpretable Machine Learning

Sponsored: EBusiness

Sponsored Session

Chair: Dokyun Lee, Carnegie Mellon University, Pittsburgh, PA, 15213, United States

1 - Interpretable Neural Networks for Computer Vision

Cynthia Rudin, Duke, LSRC / Box 90129, Durham, NC, 27708, United States

I will discuss our work on interpretable neural networks for computer vision. These networks use case-based reasoning. Their network architecture augments any standard black box neural architecture with a special prototype layer that allows the network to provide explanations for each prediction. This is not posthoc analysis, the network actually explains its own reasoning process for reaching a prediction. So far, these interpretable neural networks seem to be approximately as accurate as their black box counterparts.

2 - Explainable AI for Science and Medicine

Scott Lundberg, University of Washington, Seattle, WA, United States, slund1@cs.washington.edu

Understanding why a machine learning model makes a certain prediction can be as crucial as the prediction's accuracy in many applications. Here l will present a unified approach to explain the output of any model. It connects game theory with local explanations, uniting many previous methods. I will then focus specifically on tree-based models, such as random forests and gradient boosted trees, where we have developed the first polynomial time algorithm to exactly compute classic attribution values from game theory. Based on these methods we have created a new set of tools for understanding both global model structure and individual model predictions (http://github.com/slundberg/shap).

3 - Understanding Your Model's Errors with Errudite

Marco Tulio Ribeiro, Microsoft Research, Seattle, WA, United States

Even though error analysis is crucial to understanding and improving NLP models, the common practice of manual, subjective categorization of a small sample of errors can lead to biased and incomplete conclusions. I will present Errudite, an interactive tool for scalable, reproducible, and counterfactual error analysis. Errudite provides an expressive DSL for extracting relevant features of linguistic data, which allows users to visualize data attributes, group relevant instances, and perform counterfactual analysis at scale. User studies and case studies demonstrate that Errudite enables users to perform high quality, reproducible error analyses with less effort.

4 - Quantifying Persuasive Dialogue via Belief Hierarchies

Emaad Manzoor, Carnegie Mellon University, Pittsburgh, PA, United States, emaad@cmu.edu

Argumentation forms the grease of human decision-making machinery, enabling progress via consensus. However, many arguments result in deadlock without progress. In this work, we introduce a computational method grounded in theories of argumentation to quantify and explain successful persuasion. Our method infers a network of beliefs from argumentative text and formalizes persuasion strategies via graph-theoretic properties. We demonstrate our method on a large-scale dataset of debates on several pressing issues (such as immigration and gun control) containing ground-truth labels of argument persuasiveness to uncover several insights on the efficacy of different persuasion strategies.

■ MC71

S- Jefferson B

Behavioral Cost Accounting in OM

Sponsored: Behavioral Operations Management

Sponsored Session

Chair: James Fan, Naval Postgraduate School, Monterey, CA, 93940, United States

1 - Performance of Queuing Systems with Strategic Customers and Servers

Hung Do, PhD, University of Vermont, Burlington, VT, United States, hdo@uvm.edu

In this project, we study the impact of strategic behavior of customers and servers on the performance of queuing systems under different queue designs and incentive systems.

2 - Wait and See or Pay Now

Lijia Tan, Dr., Eindhoven University of Technology, Eindhoven, Netherlands, Rob.J.I. Basten

In business and our personal life, we usually have to make a decision on whether and when to pay a cost to avoid an unexpected loss, such as in the context of machinery maintenance and preventive healthcare. This study addresses on such individual decision in a degradation process. A dynamic cost-loss game is considered as a theoretical benchmark. We develop an experiment Our experimental results from lab show that either risk aversion or risk seeking cannot explain the overall behavior. The decision maker's behavior fall in to a specific pattern, which would be explained in this study.

3 - Social Norms in Customer-operated Service Systems

James Fan, Assistant Professor, Naval Postgraduate School, Monterey, CA, 93940, United States, james.fan@nps.edu, Mirko Kremer, Laurens G. Debo, Chen Jin

We study experimentally whether and how social norms evolve in, and affect the performance of, customer-operated service systems, where service times are (partially) endogenously determined by the customers. Our data shows that service times are positively serially correlated. We explore several boundary conditions of this phenomenon, as well as managerial levers to mitigate its adverse impact on system level metrics. Our results complement a growing literature that demonstrates the effect of system load on service times in server-operated systems.

■ MC72

S- Columbia

Advanced Data Analytics for Business Applications

Sponsored: Information Systems

Sponsored Session

Chair: Yuheng Hu, University of Illinois-Chicago, Chicago, IL, 60607, United States

1 - One Side Does Not Fit All: Personal Match and Marketing Message Effectiveness on Social Networks

Yuan Qu, Rutgers University, Newark, NJ, 07102, United States, yuan.qu@rutgers.edu, Jingyuan Yang

The goal is to improve participation and eventually marketing effectiveness of this kind of marketing (group marketing) according to user-article match. Technique-wise, this is a new problem compared to existing work. A traditional problem setting usually looks for a good match between users and product, and the goal is to maximize user interest in the product. Here our problem is the user and product match which leads to marketing effectiveness.

2 - Which Startup to Invest in: A Personalized Portfolio Strategy

Hao Zhong, Rutgers University, Harrison, NJ, 07029, United States

The screening and evaluation of startups for investment largely depends on investors' personal experiences, social relationships, and qualitative evaluation on firms. It thus has a strong call for quantitative and methodologically sound study. In this paper, we aim to develop a personalized portfolio strategy for assisting investors to target right startups and determine proper amount of capital to invest. Specifically, we develop a Probabilistic Latent Factor model to estimate investors' investment preferences in a collaborative way. Then we apply modern portfolio theory to optimize the investment strategy by considering both investment returns and potential risks.

3 - The Impact of Airbnb's Entry on Financial Delinquency

Jinan Lin, University of California, Irvine, CA, United States, Tingting Nian, Vijay Gurbaxani

We study the impact of Airbnb's entry on financial delinquency, and to the best of our knowledge, we are the first study investigating how the income shocks generated by a sharing economy platform relax liquidity constraints. By exploiting the entry of airbnb to each zip-code level, we estimate the causal effects on reducing mortgage loans, auto loans as well as bankcard loans delinquency. This paper evaluates the income shocks by utilizing excess housing capacity via an online platform, and demonstrates the economic impacts of sharing economy platform at the intersection among technology, finance and society. Our research implies that the entry of Airbnb can bring 3.99% and 2.68% reduction of mortgage loans and auto loans delinquency, and supports evidence from dynamic structures among loans delinquency and impulse-response analysis. This investigation stands with other studies supporting the welfare brought from online platform, and provides policy implication especially under the environments that U.S. households generally owe debts and remain low-liquidity assets.

■ MC73

S- Boren

Freestyle O.R. Supreme

Emerging Topic: INFORMS Section on Practice

Emerging Topic Session

Chair: Carrie Beam, University of Arkansas, Walnut Creek, CA, 94596, United States

1 - 5 Core Virtues in Data Science and Artificial Intelligence Engineering

Aaron Burciaga, Analytics2Go, Tysons, VA, 22102, United States, adburciaga@gmail.com

During this session, Aaron Burciaga CAP, Co-Founder and Principle of DataPrime, will share what characteristics typify both the professionals and programs delivering top-tier Data Science and AI Engineering. Having developed Analytics Centers of Excellence for Fortune 100 Companies, growing and leading teams of over 400 data scientists, and being key advisor to government officials on the establishment of AI programs, Aaron will share the "5 Virtues" that drive excellence in all the AI/analytics/math/... that we do.

2 - Freestyle or with Trinity Industries

Daniel Windle, Senior Data Scientist, Trinity Industries, Dallas, TX, 75207, United States, daniel.windle@trin.net

For INFORMS Freestyle O.R. Supreme, we will brief the contestants and audience on a consulting problem with participants creating a solution on the fly.

■ MC74

S- Capitol Hill

Leadership and Management Training for Women in OR/MS

Sponsored: Women in OR/MS (WORMS)

Sponsored Session

Chair: Sudharshana A Apte, Altria Client Services, Richmond, VA, 23221, United States

Co-Chair: Banafsheh Behzad, California State University, Long Beach, CA, 91101, United States

1 - Stress, Time & Procrastination: Are You a Burnout?

Kit Welchlin, Welchlin Communication Strategies, Minneapolis, MN, United States

Feeling the stress of doing more with less? Saddled with stressful situations and difficult discussions? Are you physically, psychologically and spiritually fatigued? Does the concept of work and life balance sound like a joke? Suffering burnout? Nearly half the nation's workers say job stress is destroying their mental and physical health, and eroding productivity. Kit Welchlin, one of the most requested stress management speakers in the United States, will share positive, yet practical remedies to help you feel better and more productive. During this session participants will learn 30 techniques to relieve stress, 20 time management techniques and 5 steps to stop procrastination.

■ MC77

S- Fremont

Scheduling with Batching, Gaming and Dynamic Appointment

Emerging Topic: Project Management & Scheduling

Emerging Topic Session

Chair: Zhixin Liu, University of Michigan-Dearborn, Dearborn, MI, 48126-4100, United States

1 - Pareto Optimization of Two Agents Scheduling on Parallel Batch Machines

Guoqiang Fan, Northwestern Polytechnical University, Xi'an, SN 29, China, pacpos.gqfan@gmail.com, Jun-Qiang Wang, Zhixin Liu

This paper considers a Pareto optimization problem of scheduling jobs of two competing agents on parallel batch machines with non-identical capacities. The objective is to find Pareto optimal schedules to trade-off makespans for both agents. We recognize an approximate Pareto region that covers all Pareto optimal points, and prove that any obtained point in the approximate Pareto region is 2-approximate Pareto optimal. We design an algorithm to find approximate Pareto optimal points. The computational study shows that, our obtained set of approximate Pareto optimal points is very close to the set of all Pareto optimal points, and is even equal to the set of all Pareto optimal points.

2 - Parallel Batch Machine Scheduling: Impact of Allowing Job Compatibility

Jun Xu, Northwestern Polytechnical University, Xi'an, 710072, China, pacpos.jxu@gmail.com, Junqiang Wang

We consider the scheduling problems on identical parallel batch machines with family jobs to minimize the makespan and total completion time, respectively. When jobs from incompatible families are allowed to be compatible, the impact of compatibility on each scheduling objective is investigated. We measure such impact by a ratio indicator and further prove the bound of the indicator. We investigate the cost-effective choice of allowing incompatible families to become compatible families. Furthermore, an algorithm is proposed to capture the trade-off between the value of scheduling objective and the cost of allowing compatibility.

3 - Maximizing the Number of on Time Jobson Identical Machines

Hairong Zhao, Purdue University Northwest, 2200 169 Street, Hammond, IN, 46323, United States, hairong@pnw.edu

We study the scheduling problem on identical machines. There are n jobs and each has a due date. A job has one or more tasks. The tasks can't be preempted and different tasks of the same job can be scheduled concurrently on different machines. A job is on time if all of its tasks finish before its due date; otherwise, it is tardy. The problem is to find a schedule of these jobs so that the number of on time jobs is maximized; or equivalently, the number of tardy jobs is minimized. We show that when the jobs have common due date, one can get a schedule with small absolute error. We also conduct computational experiment when the jobs have distinct due dates.

4 - Dynamic Appointment Scheduling with Random Number of Requests

Yan Zhu, Hong Kong University of Science and Technology, Hong Kong, Hong Kong, yzhubp@connect.ust.hk

We propose a new appointment policy, different from the traditional first-come-first-serve policy, for trading off between server idle time and customer waiting time. We assume that both customer service durations and the number of customers in a period are uncertain. We first use dynamic programming algorithms to construct lower and upper bounds under the first-come-first-serve policy. Then we recognize an optimality property when adding incoming customers into an existing appointment schedule. Combining the property and the bounds, we develop a branch and bound algorithm.

■ MC78

S- Greenwood

Theoretical Issues in DEA

Emerging Topic: Productivity, Efficiency and Data Envelopment Analysis

Emerging Topic Session

Chair: Andrew Johnson

1 - Technology, TFPG and Employment: A Panel Data Analysis

Arup Mitra

Please check the mobile app for this abstract.

2 - The Impact of the Facet Structure in Piecewise Linear Technologies on the Incidence of Congestion

Ole Bent Olesen, University of Southern Denmark, Denmark, ole@sam.sdu.dk, Niels C. Petersen

Estimating congestion in DEA involves the radial input contraction of a DMU towards technology with strong and weak disposability. No congestion is present if this ratio is one. With two inputs and one output and CRS all DMUs in the cone spanned by strongly efficient DMUs will be congestion free. However, this result is no longer valid when we increase the number of inputs and outputs. Sufficient conditions for this to hold in higher dimensions are presented. An example from the literature illustrates this problem.

3 - Production Functional Estimation Imposing the Regular Ultra Passum Law with Homothetic Isoquants

Xun Chen, Texas A&M University, College Station, TX, United States, xchen@tamu.edu, Yining Chen, Daisuke Yagi, Andrew L. Johnson

Nonparametric shape constrained estimators can preserve the flexibility in capturing the nuances of the data and satisfy the basic properties from theories at the same time. While global concavity is generally imposed in production function estimation, our approach generalizes this constraint by imposing Regular Ultra Passum law instead. Input isoquants are assumed to be convex and homothetic. Statistical properties are well introduced, as well as a two-step estimation algorithm.

4 - Shape Constrained Functional Estimation: Bridging Parametric Estimators and Nonparametric Estimators

Andrew Johnson, Texas A&M University, College Station, TX, United States, ajohnson@tamu.edu

Parametric estimators of production functions have been the workhorse for modeling productivity to quantify economic growth over time. The development of shape constrained nonparametric estimators have allowed researchers to relax strong parametric assumptions while still maintaining some structure on the estimator. I will review some of the existing estimators emphasizing their relationship to each other and the economic principles the shape constraints model. I will identify areas where alternative models could capture existing economic concepts and the potential benefits of research in these areas.

5 - A Revised Dynamic Data Envelopment Analysis Model with Budget Constraints

Dong-Joon Lim, Sungkyunkwan University, Suwon, Korea, Republic of, tgno3@skku.edu, Kyu-Won Lee, Moon-Su Kim

This presentation points out an unintended limitation in the conventional specification of budget constraints in dynamic DEA. It is particularly discussed that the existing model tends to underestimate the production possibilities owing to misleading assumptions, and consequently it yields overstated efficiency measures. Besides addressing the relevant issues, a revised dynamic DEA model is developed whereby one can properly take budget constraints into account in a dynamic setting while preserving the major principles of the activity analysis. An empirical case of operational assessment in fire departments is demonstrated as an example.

■ MC79

S- Issaquah A

Agriculture 4.0: Digital Revolution in Farming

Emerging Topic: Agriculture

Emerging Topic Session

Chair: Oskar Marko

Co-Chair: Vladimir Crnojevic

1 - Data Fusion for Real Time Agricultural Information Systems

Berk Ustundag, Istanbul Technical University, Istanbul, Turkey

Data has an increasing role in agricultural production and management at all scales depending on raising importance of yield efficiency and sustainability. Field level precision agriculture and basin level agricultural management are based on evaluation of various types of data and the knowledge. Remote sensing systems provide spatial information at some observation instants and real time terrestrial monitoring systems provide temporal information at some observation points. Machine Learning based Data fusion methods appear as the way of multi-temporal mapping of information and QoS management for agricultural information platforms and the services.

2 - Internet of Things (IoT)-Inspired Platform for Precision Dairy Farming

Ivan Andonovic, Strathclyde University, Glasgow, United Kingdom, Christopher Davison, Andrew Hamilton, Craig Michie, Christos Tachtatzis, Robert Atkinson

In this talk, an IoT-inspired platform will be presented that targets the provision of dairy animal health services and comprises a robust, wirelessly enabled, high node-count sensor network, gathering data from individual animals. Besides that, a cloud-based environment manages on-farm data and informs the supply chain in real time, on key operational and management interventions. These include the indicators of health state: onset of heat, important in fertility increase and hence the overall productivity, and the time spent eating and ruminating. The classifier algorithms reached the accuracy of over 98% for heat detection and >90% for the time spent eating and ruminating.

3 - Agriculture in the Big Data Era: Paradigms, Tools and Skills

Ioannis Athanasiadis, Wageningen University and Research, Wageningen, Netherlands

The agricultural digital footprint is increasing at unprecedented speed, bringing opportunities for data-driven innovation in food production. Decision-making processes are heavily influenced by big data. This talk goes through the new paradigms introduced; offer a comparative presentation across several big data applications in precision agriculture and livestock farming; and the skills needed for digital agriculture. In the big data era, the peers of agrifood chains need to change their roles and outreach beyond disciplinary silos. Teams mastering both domain expertise and data science skills are needed; but also with capabilities to communicate with stakeholders and local farmers.

4 - Data Revolution in Agricultural Insurance

Vladimir Crnojevic, BioSense Institute, Dr Zorana Djindjica 1, Novi Sad, 21000, Serbia

Agricultural insurance has an extremely important role in agri-business. While there are various insurance schemes in different countries, insurance in agriculture is still not utilizing the full potential of state-of-the-art information technology. Images coming from European Space Agency's satellites, weather parameters, artificial intelligence and big data are giving us an opportunity to estimate the true state of crops based on observations. By fusing the aforementioned technologies, we provide decision support system that dramatically improves traditional insurance and erases border between indemnity-based and index-based insurance in agriculture.

■ MC80

S- Issaquah B

TIMES Doctoral Dissertation Award

Sponsored: Technology, Innovation Management & Entrepreneurship

Sponsored Session

Chair: Pascale Crama, Singapore Management University, Singapore, 178899, Singapore

1 - Crowdfunding

Daniel Blaseg, Goethe University, Frankfurt, Germany

The overarching aim of this dissertation is to provide insights into crowdfunding beyond the time of the crowdfunding campaign. Specifically, I aim to (1) critically investigate the regulatory challenges and approaches currently applied to crowdfunding, (2) investigate the circumstances in which entrepreneurs use crowdfunding that ultimately might lead to failure, and (3) provide a reproducible data-generating process that should enable further scientific inquiry on the topic.

2 - Entrepreunerial Operations Management

Evgeny Kagan, University of Michigan, Ann Arbor, MI, United States

This dissertation examines entrepreneurship and innovation not as "phenomena", but rather as collections of more micro-level, operational or process-related questions. Addressing these questions is particularly important given the explosion of training and educational resources for fledgling entrepreneurs. Devoid of answers (or frameworks), much of the advice directed at entrepreneurs is derived from individual success stories and popular press, often driven by singular experiences of founders, and not validated by data. The purpose of this dissertation is to take some initial steps to close this gap.

■ MC81

S- Kirkland

Optimization in Petrochemicals

Sponsored: Energy, Natural Res & the Environment/Natural Resources Petrochemicals

Sponsored Session

Chair: Zukui Li, PhD., University of Alberta, AB, Canada

1 - Optimization of Linepack in Natural Gas Pipelines under Supply Uncertainty

Kody Kazda, Queen's University, Kingston, ON, Canada, 17kk18@queensu.ca, Asgeir Tomasgard, Vibeke S. Nørstebø, Xiang Li

We propose a two-stochastic programming model for optimization of linepack in gas pipeline networks under future supply uncertainty. Traditionally, the nonlinear relationships among linepacks, gas flow rates, and pressures are described with polynomial, fractional, and exponential functions, but in the proposed model, they are describe with piecewise linear functions. Case study results demonstrate that, compared to the traditional linear or nonlinear model, the proposed model can achieve higher model precision as well as better computational performance.

2 - Biorefining and Machine Learning: Towards a Universal Kinetic Model of Wood Deconstruction

Yankai Cao, University of British Columbia, Vancouver, BC, 53706, Canada, yankai.cao@ubc.ca, Heather Trajano, Edward Wang, Genpei Cai, Riley Ballachay

Hemicellulose is a major component of lignocellulosic biomass and be hydrolyzed into monomers to support biorefining transformations. Hemicellulose hydrolysis has been studied extensively, yet there lacks a universal model of this process that can be applied to multiple species and reactor conditions. In this project, the literature on hardwood hemicellulose hydrolysis is mined and used to build machine learning models. The kinetic and machine learning models (e.g. linear regression, support vector regression, and deep neural networks) are assessed on their ability to predict xylose yield.

3 - Distributionally Robust Chance Constrained Optimization with Wasserstein Distance for the Process Scheduling under Uncertainty

Yuan Zhihong, Tsinghua University, Beijing, China, zhihongyuan@mail.tsinghua.edu.cn, Botong Liu

Distributionally robust chance constrained programming (DRCCP) is a framework containing a set of uncertain probabilistic constraints which are supposed to be satisfied a specified value under distributions of uncertain variables. In the present work, the ambiguity set employed was the Wasserstein metric centered at the empirical distribution. We derived a tractable dual reformulation of the DRCCP problem when proper norm spaces were chosen for the Wasserstein metric. The effectiveness of the proposed reformulation was demonstrated by scheduling cases of batch chemical plant.

4 - Adaptive Nonlinear Robust Optimization of Water Treatment Network Design under Uncertainty

Zukui Li, University of Alberta, Edmonton, AB, T6G1H9, Canada, zukui@ualberta.ca, Sanjula Kammammettu

We present a nonlinear robust optimization method for the optimal design and operation of the wastewater treatment network under uncertainty. The problem is formulated as a two-stage mixed-integer nonlinear optimization problem under uncertainty, where the variables are classified into design, state and control variables. The solution method is based the linearization with respect to uncertain parameters and the application of decision rule to control variables. Applications on water treatment network for in-situ oil sands extraction process shows that the method can lead to robust water network design and adaptive operation policies for different ranges of uncertainty.

■ MC82

S- Leschi

Sustainability and Social Responsibility in Commodity Supply Chains

Sponsored: Energy, Natural Res & the Environment/Environment & Sustainability

Sponsored Session

Chair: Jan C. Fransoo, Kuehne Logistics University, Hamburg, 20457, Germany

1 - Reveal the Supplier List? A Trade-off in Capacity vs. Responsibility

Basak Kalkanci, Georgia Institute of Technology, 815 Creekgarden Court, Atlanta, GA, 30339, United States, Erica Plambeck

Some buying firms, facing scrutiny regarding social and environmental violations in their suppliers' operations, have recently made commitments to publish the identities of their current and/or terminated suppliers. In this paper, we study the trade-offs faced by a buying firm in deciding whether or not to make such transparency commitments. We identify the conditions under which a buying firm should commit to publish its supplier list, and the conditions under which the buying firm should make complementary investments to help the supplier become more productive.

2 - Social Equity in Supplier-Buyer Relationships in Smallholder Agri-food Supply Chains

Nayeli Hernandez-Martinez, Eindhoven University of Technology, Eindhoven, Netherlands, n.hernandez.martinez@tue.nl, Nevin Mutlu, Jan C. Fransoo

We study supplier-buyer relationships in smallholder agri-food supply chains with equity concerns and under stakeholder engagement. We develop a Stackelberg game model to study the impact of these socially responsible practices in investment and pricing decisions. We provide closed form expressions for the optimal prices and characterize the structure of the optimal investment. We numerically study the effect of the model parameters and the price of ignoring equity concerns. We show that equity concerns may reverse the advantage of the game leader and that, under the right circumstances, the introduction of socially responsible practices can increase the total supply chain profit.

3 - Do Policies with Limited Enforcement Reduce Harm? Evidence from Transshipment Bans

Joann de Zegher, MIT Sloan, Cambridge, MA, 02142, United States, jfz@mit.edu, Hamsa Sridhar Bastani

To mitigate environmental and social harm in supply chains, buyers often provide incentives or impose sanctions to suppliers. Such policies are often implemented with limited monitoring and enforcement, which may lead to strategic behavior by suppliers and unintended consequences. We study empirically if a policy with limited enforcement can reduce harm, leads to strategic behavior, and increases raw material costs. We combine modeling with remote sensing data, and exploit variation over time and space to develop a conservative estimate of the effect of a ban on seafood transshipments. Our results inform the debate on such bans, which is hoped to mitigate forced labor and illegal fishing.

4 - The Impact of Animal Welfare Regulation on Firms' Product Offerings: Humane or Organic Product

Yen-Ting (Daniel) Lin, University of San Diego, School of Business Administration, San Diego, CA, 92110, United States, linyt@sandiego.edu, Wenli Xiao, Yinping Mu

We consider two competing supply chains with a supplier and a retailer. We examine the retailers' choice between offering an organic product and a humane product, when an animal welfare regulation is introduced. By offering an organic product, the retailer improves both animals' living conditions and the product's nutritional benefits, while offering a humane product only improves animals' living conditions. We provide the conditions under which the retailer would choose to offer the organic versus humane product. In addition, we show that subsidies offered by regulators to encourage the consumption of humane product in general hurts social welfare.

■ MC83

S- Medina

ENRE Award Session

Sponsored: Energy, Natural Res & the Environment/Electricity

Sponsored Session

Chair: Sandra D. Eksioglu, Clemson University, Clemson, SC, 29634, United States

1 - Award Presenter

Sandra D. Eksioglu, Clemson University, Department of Industrial Engineering, Clemson, SC, 29634, United States

In this session, the winners of the 2019 ENRE Awards will be announced and their certificates will be handed out. One representative of each award winning group will make an approximately 10-minute presentation of their award-winning work.

■ MC84

S- Ravenna A

The Challenges of Going Green: Solutions for Utilities and Firms

Sponsored: Energy, Natural Res & the Environment/Energy

Sponsored Session

Chair: Benjamin D. Leibowicz, University of Texas-Austin, Austin, TX, 78712-1591, United States

1 - Black-box Optimization for Design of Photovoltaic and Concentrating Solar Power Hybrid Systems

William T. Hamilton, Graduate Student, Colorado School of Mines, Golden, CO, 80218, United States, whamilton@mines.edu, Alexandra M. Newman, Robert J. Braun

Concentrating solar power (CSP) technologies capture thermal radiation from the sun. When paired with thermal energy storage (TES), CSP systems are a dispatchable renewable energy source. The hybridization of photovoltaic (PV) and CSP with TES systems has the potential to provide continuous energy production at a lower cost than a PV or CSP system alone. We evaluate hybrid system designs using a black-box optimization solver, and optimize corresponding dispatch decisions for a given geographic location and electricity market structure. We present preliminary results with an emphasis on system design trade-offs based on system requirements.

2 - Optimizing the Design and Dispatch of Combined Heat and Power Technologies

Joshua Pearson, Colorado School of Mines, Golden, CO, 80226, United States, jpearson@mines.edu, Alexandra M. Newman, Tulay Flamand, Josiah Pohl, Alexander Zolan

We enhance a model developed by the National Renewable Energy Laboratory to incorportate combined heat-and-power technologies with existing photovoltaics, batteries and wind. The model determines a cost-minimizing collection of technologies subject to load, operational, and logical constraints. We develop methodologies to improve tractability of this mixed-integer program, and analyze results for a set of regions within the United States.

3 - Harvesting Solar Power Foments Prices in a Vicious Cycle: Breaking the Cycle with Price Mechanisms

Metin Cakanyildirim, The University of Texas at Dallas, Jindal School of Management, 800 W. Campbell Road Sm 30, Richardson, TX, 75080, United States, metin@utdallas.edu, Fariba Farajbakhsh

Growth of residential solar power in a market benefits the environment but not necessarily the (utility or transmission) firms. It reduces the residential power demand and hence hinders the coverage of fixed part of generation and transmission costs with reasonable prices. The firms tend to raise the retail prices and make electricity less affordable for their consumers. We provide a novel revenue maximization formulation for a regulated firm and analytically reveal the connection between price increases and solar penetration. We also extend this formulation to take into account new price structures that mitigate price increases by allowing for the coverage of fixed costs in part or full.

4 - Meeting Corporate Renewable Power Targets

Danial Mohseni-Taheri, College of Business, University of Illinois at Chicago, Chicago, IL, 60610, United States, smohse3@uic.edu, Selvaprabu Nadarajah, Alessio Trivella

Prominent companies have committed to procuring a percentage of their power demand from renewable sources by a future date. We study procurement portfolios to achieve this target based on two dominant strategies: Long-term procurement of power and short-term purchases. We analyze a two-stage model to understand the behavior of procurement costs when using popular corporate power purchase agreement (CPPA) variants employed in practice. Finding the optimal multi-stage procurement portfolio gives rise to an intractable Markov decision process. To overcome this intractability, we develop a novel dual reoptimization heuristic and highlight the benefits of using CPPAs to meet a renewable target.

■ MC85

S- Ravenna B

Economic Development, Energy and Climate

Sponsored: Energy, Natural Res & the Environment/Energy Sponsored Session

Chair: Yongyang Cai, Ohio State University, Columbus, OH, United States

1 - Modeling the Feed-in Tariff and Renewable Energy Certificates Schemes in U.S. Electricity Market

Ziyu Guo, The Ohio State University, Columbus, OH, United States, guo.645@buckeyemail.osu.edu

In the U.S., feed-in tariffs (FITs) and renewable energy certificates (RECs) are two main policy tools to encourage electricity generation from renewable energy. FITs offers a specific amount of payment to renewable energy producers for the electricity they produce. RECs requires electricity producers to supply a specific percentage of their electricity generating from renewable resources by a specified year. To compare the effects of the two schemes, this paper builds a dynamic model to simulate the electricity generations under two systems. The results indicate that, FITs can induce more renewable energy production than RECs. But the total production of electricity is uncertain over time.

2 - Geospatial Optimization of Infrastructure for CO2-based Geothermal Electricity Generation

Marcos Miranda, Ohio State University, Columbus, OH, United States, Jeffrey M. Bielicki, Jonathan Ogland-Hand, Stephen Maldonado, Christina Howard, Benjamin Adams, Martin Saar, Richard Stephen Middleton

Carbon dioxide (CO_2) based geothermal electricity production can simultaneously isolate CO_2 from the atmosphere and generate dispatchable baseload electricity. We investigated the viability of this approach by adapting an engineering-economic geospatial optimization model, SimCCS, to investigate the optimal deployment of infrastructure for systems that capture and transport CO_2, inject that CO_2 into sedimentary basin geothermal resources, and circulate that stored CO_2 to extract geothermal heat and convert it into electricity. We found a few regions in the United States that may be viable, if amenable by policy.

3 - Forecasting of Durable Consumer Goods under Uncertainty: A Non-standard Difference Numerical Scheme

Hongbo Duan, University of Chinese Academy of Sciences, Beijing, China, hbduan@ucas.ac.cn

The discretization method of these diffusion models becomes one of critical techniques to affect the effect of parameter estimation and product prediction. In this paper, a nonstandard finite difference numerical scheme is developed to approximate stochastic differential models and generate the one-step ahead conditional transition density, which finally contributes to achieve better parameter estimations and predictions than the traditional Euler-Maruyama discretization scheme. We attempt to predict the future sales of China's electric vehicles in the context of proposed discretization scheme, and we obtain more accurate predications as compared to the traditional methods.

4 - Climate Policy under Spatial Heat Transport: Cooperative and Noncooperative Regional Outcomes

Yongyang Cai, Ohio State University, Columbus, OH, 43210, United States, cai.619@osu.edu, William Brock, Anastasios Xepapadeas, Kenneth Judd

We build a novel stochastic dynamic regional integrated assessment model of the economy and climate system with spatial heat transport from the Equator to the Poles, sea level rise, permafrost thaw and tipping points. We study optimal policies under cooperation or noncooperation between two regions (the North and the Tropic-South) in the face of risks and recursive utility. We find that ignoring elements of climate science leads to serious biases in important policy variables such as the regional social cost of carbon (SCC) and adaptation. We also find the regional SCC is significantly smaller in the feedback Nash equilibrium than in the social planner's problem for each region.

5 - Effect of Coal Transportation Inefficiencies on Indian Wholesale Power Generation

Jevgenijs Steinbuks, The World Bank, Washington, DC, United States, JSteinbuks@worldbank.org, Puneet Chitkara, Shefali Khanna

This study assesses the effect of inefficiencies in coal transportation by Indian Railways on the productivity of Indian wholesale power generation. The stochastic frontier analysis is applied to the plant level electricity generation data to determine electricity generation efficiency. Using the state-level data of passenger and coal freight schedules and tariffs, we optimize the coal dispatch to thermal generators accounting for the railroad route capacities and interstate transmission constraints. The optimal coal dispatch is used as an instrumental variable to obtain the econometric identification of the causal effect of coal transportation on thermal generation efficiency.

■ MC86

S- Ravenna C

Towards Fully Integrated Energy Systems: From Long-term Planning to Short-term Operations

Sponsored: Energy, Natural Res & the Environment/Energy Sponsored Session

Chair: Stefanos Delikaraoglou

Co-Chair: Conor Malley

1 - Thermostatically Controlled Loads as Demand Response Providers: A System and Aggregator Perspective

Kenneth Bruninx, KU Leuven, Celestijnenlaan 300, post box 2421, Leuven, B3001, Belgium, kenneth.bruninx@kuleuven.be

The flexibility of thermostatically controlled loads may hold significant value for the power system and be monetized by aggregators, acting as mediators between consumers and the electricity market. We study (i) this flexibility from a power system perspective and (ii) the strategic interactions between an aggregator, its consumers and the wholesale market. In both cases, the demand response resources' limited controllability is accounted for via chance constraints. The presented methodology may be used to assess the value of DR in a deregulated power system.

2 - Unlocking Linepack Flexibility from Natural Gas and District Heating Networks: Convexification Approaches

Anna Schwele, Technical University of Denmark, Kgs Lyngby, Denmark, Charlotte Vervaeren, Adriano Arrigo, Jalal Kazempour, François Vallee

We model an integrated energy dispatch to reveal the maximum potential of linepack, i.e., energy storage in natural gas and district heating pipelines, to provide operational flexibility for the power system. Accounting for dynamics of natural gas flow and time delay of heat transport introduces nonlinearities and nonconvexities. We explore mixed-integer convex quadratic relaxations for linepack modeling and recast the original MINLP as a MISOCP. Ex-post analysis ensures feasibility of the heat dispatch while keeping the relaxation of the gas flow model tight. Flexibility is quantified in terms of system cost compared to a dispatch model neglecting the natural gas and district heating networks.

3 - Benders Decomposition with Adaptive Oracles for Large Scale Optimization

Nicolo Mazzi, University of Edinburgh, Edinburgh, United Kingdom, nicolo.mazzi@ed.ac.uk, Andreas Grothey, Ken McKinnon

We propose an algorithm to solve large stochastic investment planning problems for power system expansion, where subproblems differ in right-hand side and cost coefficients. Similar problems are often tackled using cutting-plane algorithms, which may slow down severely when solving subproblems is computationally expensive. We propose two adaptive oracles that yield inexact information much faster than solving the subproblem. The first oracle generates inexact but valid cutting planes, and the second oracle gives a valid upper bound of the true optimal objective. These adaptive oracles are embedded within a Benders algorithm to substantially reduce the effort to obtain a -optimal solution.

4 - Primal Decomposition of Gas and Electric Network Optimization

Conor O. Malley, ETH Zurich, Physikstrasse 3, Zurich, 8092, Switzerland, omalleyc@eeh.ee.ethz.ch

The increasing use of natural gas-fired generators in power systems can cause an interdependency between the electrical network operation and the gas network operation. In order to choose an optimal dispatch for both the gas and electric systems a combined optimal gas and optimal power flow problem can be solved. The complexity of this problem, and hence the solution time, for this problem can grow with the size of the networks and the number of time-steps that are considered. To overcome this problem, recent literature has proposed the use of dual decomposition strategies, but in this work a primal decomposition strategy is investigated and compared with the dual decomposition approaches.

■ MC92

S- Grand Ballroom A

Supply Chain Optimization I

Contributed Session

Chair: Rupei Xu, University of Texas, Dallas, Richardson, TX, 75081, United States

1 - Last-mile Delivery: Optimal Locker Location under Multinomial Logit Choice Model

Yunhui Lin, National University of Singapore, Singapore, linyunhui@u.nus.edu, Yuan Wang, Loo Hay Lee

In today's E-commerce, locker systems for last-mile delivery have drawn intense attention from logistics companies. Recently, Singapore Post has launched a "Locker Alliance", which offers an access delivery network comprising of parcel lockers and collection points to enable customers to collect parcels at their convenience. In this work, we study the location of locker stations, considering the preference of customers, with the objective to minimize the walking distance. The customer's preference is modeled by a multinomial logit choice model. We conduct a case study based on the existing locker system of Singapore and derive managerial implications.

2 - A Three-stage Heuristic Algorithm for the Capacitated Vehicle Routing Problem

Maryam Abdirad, Wichita State University, Wichita, KS, United States, Krishna Krishnan

Industry 4.0 focuses on mobility and real-time integration and is a good framework for a Dynamic Vehicle Routing problem (DVRP). VRP problems are computationally intensive and often infeasible. In order to find the best solution for a scheduling system for delivery vehicles, a hierarchical approach consisting of three-stage solution with "cluster-first route-second" is proposed. The results of this approach confirmed the proposed methodology is applicable.

3 - Integrated Supply Chain Network Design for Perishable Products

Gang Wang, University of Massachusetts-Dartmouth, North Dartmouth, MA, United States

This paper studies a multi-echelon supply chain design considering production scheduling and lead times. We propose a mixed-integer linear programming model and a two-phase solution approach. Furthermore, we perform computational experiments on the randomly generated datasets and assess computational performance regarding network size, demand variability, and relative penalty costs.

4 - A Dual Sourcing Inventory Model for Modal Split Transport: Structural Properties and Optimal Solution

Chuanwen Dong, ESCP Europe, Berlin, Germany, cdong@escpeurope.eu, Sandra Transchel

We generalize the classical tailored base-surge dual sourcing inventory model by introducing a fixed cost in the slow mode (rail), adding an extra decision in its delivery frequency, and relaxing the assumption of the base stock control of the fast mode (road), to support firms' modal split transport optimization. We obtain properties of this problem, which allows to find the optimal solution using stochastic dynamic programming with realistic computing effort. Finally we analyze the sensitivity and robustness of our model using values suggested by a consumer goods firm.

5 - Effect of Flexible Delivery Windows During Multi-period Vehicle Routing

Aliakbar Izadkhah, Carnegie Mellon University, Pittsburgh, PA, United States, aizadkha@andrew.cmu.edu, Anirudh Subramanyam, Jose M. Lainez-Aguirre, Jose M. Pinto, Chrysanthos E. Gounaris

We study the effect of flexible delivery day windows on the optimal solutions of multi-period vehicle routing problem (MPVRP) under customer order uncertainty. We develop a simulation engine that supports multiple decision policies, including myopic policies often practiced in real life, as well as more sophisticated, look-ahead policies (both deterministic and robust). The engine addresses weekly snapshots using an exact MPVRP solver, adopts the routes for the first day, and repeats the procedure in a rolling horizon fashion. Computational studies on literature benchmarks allow us to quantify the overall distribution cost savings that customer flexibility in delivery windows provides.

6 - The Last Mile Flying- An Improved Approximation Algorithm for the Traveling Salesperson Problem with Drone

Rupei Xu, The University of Texas at Dallas, Richardson, TX, United States, rupei.xu@utdallas.edu, Andras Farago

With the development of new delivery technologies, drones are adopted to provide faster and more cost-efficient home delivery services, which leads to an innovative approach—the last-mile delivery. The combination of a traditional truck, which can release drones for the "last mile," and then recaptures them, defines the novel optimization problem called Traveling Salesperson Problem with Drone (TSP-D). In the existing literature, some heuristic methods are presented to find solutions for practical settings. However, there exists only a very limited theoretical performance analysis. This paper provides an improved approximation algorithm, along with theoretical analysis.

■ MC93

S- Grand Ballroom B

Information Systems V

Contributed Session

Chair: Nicholas Brown, Virginia Tech

1 - Spillover Effects of Participating in Contests in Online Health Communities

Zhijun Yan, Beijing Institute of Technology, Haidian DistrictBeijing, 100081, China, yanzhijun@bit.edu.cn, Han Yang, Lin Jia, Lini Kuang, Chenxi Guo

Nowadays, crowdsourcing contest has become an efficient channel for people to seek for help. We focus on crowdsourcing contest section of a focal online health community, in which doctors are no longer anonymous and provide services in different sections other than crowdsourcing contests. This allows us to explore the spillover effect of doctors' participation in contests on their reputation and performance. The results indicate that doctors' participation will increase their online consulting performance, online ratings, and number of fans. On average, their participation does not affect their number of offline appointment.

2 - Software Development Kit Network and Mobile App Success

Xia Yu, City Univeristy of Hong Kong, Hong Kong, yuxia25-c@my.cityu.edu.hk, Chen Hailiang

The adoption of third-party Software Development Kits (SDKs) in mobile app development is becoming increasingly popular. While the impact of SDKs on app success has not been well examined. This study aims to quantify the effect of SDK adoption on mobile app performance and in particular focuses on the role of SDK network. Our dataset covers all mobile apps released on both Apple App Store and Google Play from 2008 to 2018. Mobile app performance is measured by the number of app downloads and revenues. We use the number of apps that install two SDKs at the same time to denote the strength of the SDKs' connection. Our findings would help app developers better understand the role of SDKs in mobile app development.

3 - Investigating Value Co-creation in Outdoor Adventure Mobile Apps

Hossein Kalantar, University of Colorado Denver, Denver, CO, United States, hossein.kalantar@ucdenver.edu

There are certain types of mobile applications that guide users for outdoor activities. These applications provide a crowdsourcing platform where users can find, create, and share related contents such as maps, photos, directions, and reviews of hiking, running, and biking trails. Although the primary geospatial data is provided in these platforms, their success is highly tied to the active participation of users. In this study, we conduct an empirical analysis to determine the main factors that lead to users' participation and value co-creation in these platforms.

4 - Effect of Gamification Elements on Activities of Stack Overflow

Jaewan Lim, University of North Carolina at Charlotte, Charlotte, NC, United States, jlim13@uncc.edu, Dongsong Zhang

Collective intelligence plays a critical role in developing a wide range of knowledge in the online community. Particularly, user spontaneity has a great impact on scaling the network of collective intelligence. If users do not contribute efforts spontaneously to the online community, the quantity and quality of Q&A will worsen. To date, Stack Overflow hosts more than 16M questions and 24M answers. One of the strategies that the site motivates users to be spontaneous is gamification. In the study, we mainly explore how gamification elements affect user's Q&A activities in the Stack Overflow.

5 - Measuring User Experiences of Techfin Mobile Apps from the Cognitive Science Perspective

Songhyun Kim, Yonsei University, Seoul, Korea, Republic of, hci.researcher.kim@gmail.com, Junseok Goh

In a dynamic environment where Internet Primary bank and other Techfin services keeps growing and technology evolves, financial mobile applications have gained popularity. With advent of technology and the changes in the perceiving UX/UI, this paper looks into the altering process of how users trust and adopt financial apps. Especially millennials make transaction and manage their asset in daily life, using apps. Thus, we examine Techfin service users from the cognitive science perspective, unveiling the purpose and the patterns of usage UI/UX of millennials. Methodology will primarily be based on archival data, survey data with Lab testing of individual's usage and evaluations of the apps.

6 - An Active Choice Inbox Management System to Reduce Email Clutter

Nicholas Brown, Doctoral Student, Virginia Tech, Blacksburg, VA, United States, nichb15@vt.edu

This study deals with email clutter inside an inbox. Email users have indicated that email overload can become a source of strain. The aim of this study is to create an artifact that will help reduce email clutter. The Vinish artifact is an active choice inbox management system that uses colored labeling inside Gmail, along with the active choices of "keep" and "later" to help users manage their inbox more effectively. Based on a preliminary qualitative study, the results show that the use of active choice labeling can be useful in reducing the number of emails within inboxes.

■ MC94

S- Grand Ballroom C

Academic Job Search Panel

Emerging Topic Session

Chair: Warren Hearnes, Cardlytics, Lilburn, GA, 30047-7417, United States

1 - Academic Job Search Panel

Warren Hearnes, Cardlytics, Lilburn, GA, 30047-7417, United States

This panel discusses the academic interview process and do's and don'ts associated with the job search. In addition to comments by current and former search chairs, time will be provided for questions and answers.

Panelist

- Priyank Arora, University of Massachusetts-Amherst, Amherst, MA, 01003, United States
- Thiago Serra, Bucknell University, Cambridge, MA, 02139, United States
- Opher Baron, University of Toronto, Toronto, ON, M5S 1L7, Canada
- Karmel S. Shehadeh, Carnegie Mellon University, Hamburg Hall, Pittsburgh,, Pittsburgh, PA, 15213, United States
- Haifeng Wang, Mississippi State University, Starkville, MS, United States
- Kejia Hu, Vanderbilt University, Nashville, TN, 37215, United States

■ MC95

S- Grand Ballroom D

INFORMS Korea Chapter (KINFORMS)

Sponsored: INFORMS Special Sessions

Sponsored Session

Chair: Chang Won Lee, Hanyang University, Seoul, 133-791, Korea, Republic of

1 - Study on Smart Factories and Services: Korea Cases

Chang Won Lee, Hanyang University, School of Business, Seoul, 133-791, Korea, Republic of, leecw@hanyang.ac.kr, kijun Lee

We will analyze the level of smart factories in the current market by analyzing the theoretical review and actual cases of implementation and implementation of smart factories in Korea.

2 - Emergency Medical Services' Impact on Brand Equity

Sungyong Choi, Associate Professor, Yonsei University, Wonju, Korea, Republic of, sungyong.choi@yonsei.ac.kr, Ki-Young Kim, Yunsik Choi, Jiyeon Choi

This empirical study gauged the impact of the public's perception of the relationship between the emergency medical service, public health system, and level of system governance in South Korea. We developed a survey to measure how the key activities of the emergency medical service (EMS) are perceived. First, the public's perception of the EMS affected the development of brand equity in the public health system. Third, the public perception of governance played a moderating role on the relationship between EMS activities and the brand of the public health system.

3 - Are Proactive Services Beneficial?: An Event Study

Youngmi Han, Korea University Business School, Seoul, Korea, Republic of, 55835729@hanmail.net, Chulok Ahn, Hosun Rhim

Customer needs are constantly increasing. While reactive behavior of enterprise does not satisfy the changing customer needs, proactive behavior prevents potential problems and creates values. Previous study defined proactive services, and classified them into three types. In this study, we analyze event data to empirically study consequences of implementing proactive services.

4 - Designing and Managing Wastewater Treatment Planning for River-Basin in Developing Countries

Kwon Gi Mun, Fairleigh Dickinson University, Teaneck, NJ, United States, kgmun@fdu.edu, Jiyong Eom, Yao Zhao

Designing and managing wastewater treatment for riparian states has become a highly controversial policy issue since their asymmetric externality relationships and vulnerability positions. The problem is particularly pronounced in low-income countries facing tight public budgets and development uncertainties. We develop the concept of wastewater management by proposing a spatially, temporally, and technologically explicit optimization model using the case of Ganga river in India.

Monday, 3:10PM - 4:00PM

■ Keynote

CC- Room 6C

Keynote: Alleviating Poverty & Inequity: Fresh Challenges for Business Model Innovation

Emerging Topic: Keynote

1 - Alleviating Poverty & Inequity: Fresh Challenges for Business Model Innovation

Kamalini Ramdas, London Business School, Regent's Park, London, NW1 4SA, United Kingdom

Poverty and inequity remain two of the most pressing challenges in today's world. Meanwhile, business model innovation is transforming business across the globe, creating new wealth by combining innovative operational thinking, data and analytics to unleash previously untapped sources of value. This talk will examine the opportunity for business model innovation to alleviate poverty and inequity, showing how our community can play an important role. I will discuss how business model innovations can alleviate poverty by simultaneously empowering women, increasing incomes, and creating low-cost, high-quality and environmentally sustainable products or services. I will highlight opportunities for high-impact research that require different forms of modelling expertise, including econometrics and data science.

■ Keynote

CC- Room 6B

Keynote / MSOM Fellow: The New Age of Healthcare Delivery

Emerging Topic: Keynote

1 - The New Age of Healthcare Delivery

Linda Green, Columbia University, New York, NY, United States

The U.S. healthcare system is undergoing one of the most rapid periods of change ever. The confluence of new payment systems, technological innovations, greater data availability and higher consumer expectations is resulting in a new focus on increasing access and convenience, particularly for high-risk, high-needs patients, while controlling costs through greater reliance on evidence-based care and increasing productivity. While hospitals and physicians have dominated the healthcare delivery system in the past, new models of healthcare delivery employ a variety of locations and types of providers, raising questions about the best means to deliver cost-effective care. In this talk I'll describe these operational and organizational innovations and the critical research questions that must be addressed to create higher quality, lower cost healthcare systems in the future.

■ Keynote

CC- Room 6A

Keynote: Zero Carbon Analytics (IFORS Distinguished Lecture)

Emerging Topic: Keynote

1 - Zero Carbon Analytics (IFORS Distinguished Lecture)

Andy Philpott, University of Auckland, Dept of Engineering Science, Private Bag 92109, Auckland, New Zealand

Climate change from global warming is the most critical problem currently facing mankind. The deleterious effects of global warming have already been felt in 2019 in terms of storms, heatwaves and forest fires. Climate-based natural disasters in the longer term threaten to be much worse. Policies to deal with this problem must combine efforts to reduce global warming by eliminating greenhouse gas emissions with actions that adapt to worsening climate outcomes. Determining the best policy settings is a highly complex decision problem, involving complex interacting systems and markets, many stakeholders, many decision criteria, and huge uncertainty. In other words, it is a major opportunity for operations researchers. This talk will illustrate some of the analytics challenges in planning a net-zero carbon economy with a focus on electricity systems. Models range from short-term operations (like dealing with intermittent renewable energy) to long-term investment planning to ensure security of energy supply in an uncertain future. Planning models are complemented with equilibrium models that represent the effects of risk-averse agent behaviour. The models will be illustrated with a New Zealand case study based on our recent work for the New Zealand Interim Climate Change Committee in planning a 100% renewable electricity system.

■ Keynote

CC- Room 6E

Keynote: INFORMS AI Strategy: Opportunities at the Intersection of AI and Operations Research

Emerging Topic: Keynote

1 - INFORMS AI Strategy: Opportunities at the Intersection of AI and Operations Research

Ramayya Krishnan, Carnegie Mellon University, Pittsburgh, PA, United States; Pascal Van Hentenryk, Georgia Tech University, Atlanta, GA, United States

From driverless cars to deep learning, from AlphaGo to poker, from health care diagnosis and delivery to smart operations, applications of Artificial Intelligence (AI) have captured public imagination and become an active topic of discussion among leaders in all sectors. The Trump administration released an executive order on AI (see https://www.whitehouse.gov/ai/) and held a White House summit in September 2019 on "Public Sector Implementation of AI" (https://www.whitehouse.gov/wp-content/uploads/2019/09/Summary-of-White-House-Summit-on-AI-in-Government-September-2019.pdf). As a community and discipline that has long focused on developing solutions to important societal and business decision problems, what should our posture as a society be to these developments in AI? In this keynote presentation, we will present the key ideas underlying the AI strategy for INFORMS and the work already underway that will find ways for members to benefit from the rise of AI. This will draw on the work done by the board, the AI strategy committee, and countless members of INFORMS.

Monday, 4:30PM - 6:00PM

■ MD01

CC- Room 201

Data Mining, Machine Learning, and Artificial Intelligence in Banking, Financial Services, and Insurance (BFSI) Sector: Concepts, Cases and Applications

Sponsored: Data Mining

Sponsored Session

Chair: Darshan Desai

1 - Art and Science of Designing Machine Learning and AI Applications in Financial Services

Rahul Bedi, Berkeley College, New York, NY, United States, rbe@berkeleycollege.edu, Debasish Das, Darshan Desai

As the science of harnessing intelligence from data ("information insights") evolves rapidly, due to emergence of superior, faster and cheaper computing resources, it is now imperative that the artists within us are powered with the right tools and frameworks for creating the narrative which evokes positive socio-economic response from the beneficiaries of Machine Learning (M/L) and AI based applications. This paper discusses potential areas of M/L and AI based applications in financial services industry and outlines key design considerations for building solutions leveraging power of data science and providing artistic freedom for driving responsible innovation.

2 - Use of Artificial Intelligence to Enhance Fiduciary Duties of International Financial Institutions by Incorporating Text Mining Into Audit Planning

Kitty Kay Chan, Professor of Professional Practices, Columbia University, New York, NY, United States

International Financial Institutions (IFIs) often provide loans to member countries to fund projects that advance economic and social development. To ensure the funds are used for the intended purposes, IFIs conduct audits of the financed projects. It is important to be able to identify high-risk areas as it is not possible to examine all projects at a reasonable cost. To help address this challenge, this presentation will discuss the application of text mining techniques in audit planning.

3 - Risks Associated with Deep Learning Algorithms: Implications on BFSI Sector

Darshan Desai, Berkeley College, New York, NY, United States, Om Desai

The use of deep learning algorithms, like the algorithms used in some autonomous cars, can influence risk profiles of BFSI customers. Many of the firms in this sector are facing challenges in identifying risks associated with deep learning algorithms in an effective and timely manner. Additionally, these risks can manifest in unfamiliar ways and may evolve over time, sometimes very rapidly, as deep learning models learn and evolve. This presentation discusses methods of identifying the risk-parameters and developing risk-classification associated with deep learning models.

■ MD02

CC- Room 202

Teaching Data Mining to Business Students

Sponsored: Data Mining

Sponsored Session

Chair: Vijay Mehrotra

1 - Planting Analytics: A Journey Through Creating a Business Analytics Curriculum.

Majid Karimi, California State University, San Marcos, San Marcos, CA, United States

We present our experience with designing a curriculum to meet the demand of the ever-growing number of students and industry partners for a robust Business Analytics Program. We were faced with many challenges such as teaching R to students with little to no coding background, bringing big business real-world data into classrooms, making the program accessible to full-time students as well as part-time students, and most importantly creating an influential capstone project which spans across three courses of Descriptive Analytics, Predictive Analytics, and Prescriptive Analytics.

2 - Designing Data Mining Course for Business Data Analytics

Zinovy Radovilsky, California State University, East Bay, Hayward, CA, United States, zinovy.radovilsky@csueastbay.edu, Vishwanath Hegde

The interdisciplinary nature of the data mining (DM) subject poses a number of challenges while teaching this subject in a business program. A DM course can be introduced by a variety of departments/disciplines including statistics, computer science and business; within business it can be taught by faculty from multiple disciplines. The DM course may emphasize various dimensions, i.e., machine learning algorithms, statistical methods, and business applications. The DM course may be also taken by students from multiple programs, and thus a student preparedness along the specified dimensions varies. We explain how the DM course should be designed given the complexity of its dimensions.

3 - Business Analytics Programs at William & Mary's Mason School

James Bradley, College of William and Mary, Williamsburg, VA, United States, james.bradley@mason.wm.edu

William & Mary's Raymond A. Mason School of Business has reinvented its undergraduate operations management major as a business analytics major. It has also introduced two new Masters of Science in Business Analytics programs, one of which is a traditional in-residence program and another of which is online. This talk describes the design approach and structures of these new programs.

4 - **Teaching Data Mining to MBA Students: Some Lessons and Some Questions**

Vijay Mehrotra, University of San Francisco, School of Business and Professional Studies, San Francisco, CA, 94117, United States, vmehrotra@usfca.edu

In teaching Predictive Modeling and Data Mining to a non-technical population of MBA students, I have evolved my course content and teaching approach significantly over the past several years. In this presentation, I describe my journey, share some lessons learned, and solicit input from audience members about how to make the course more effective and relevant.

■ MD03

CC- Room 203

Data Analytics in Online Communities

Sponsored: Data Mining

Sponsored Session

Chair: Jane Tan

1 - **The Predictive Power of Discrete Emotions in Microblogging Messages: An Empirical Study in the Movie Industry**

Yifan Yu, University of Washington, Seattle, WA, United States, Jinghua Huang, Yong Tan

This paper generates daily box office prediction by conducting discrete emotion analysis on microblogging messages. Eight kinds of discrete emotions are empirically found to be predictive to box office. We also find discrete emotions have higher predictive power than valence, indicating that discrete emotions can better delineate consumer sentiment than valence can. Love, disgust, expect and anxiety are the four emotions with the highest predictive power. Each of them can individually produce higher prediction accuracy than valence. This study also proposes a methodology for automatic domain-specific emotion lexicon construction with Word2Vec model.

2 - **Impact of Live Streaming on Online Sales: A Deep Learning Approach**

Cheng Chen, University of Illinois-Chicago, University Hall, Chicago, IL, 60607, United States, cchen224@uic.edu, Yingda Lu, Yuheng Hu

Recent years have witnessed an explosive growth in online live video streaming. With the rise of live streaming in popular culture, it has begun to attract interest from the research community. Recent research has shown that the adoption of live streaming has an impact on online selling. Live streaming, reducing product uncertainty by providing rich information, significantly increases online product sales. The literature, however, remains unanswered regarding the mechanism of the effect of adopting live streaming on online sales. In this study, we propose to analyze the content of live streaming and analyze the effect of the factors during live streaming on online product sales.

3 - **A Latent Class Model of Player Reward Ads Watching Behaviors in Online Mobile Games**

Jiaying Deng, University of Washington, Seattle, WA, 98105, United States, jydeng2@uw.edu, Stephanie Lee, Yong Tan

This paper investigates an emerging monetization mechanism - reward ads. Specifically, a latent class model is proposed to examine what factors affect player reward ads watching behavior and how it relates to player engagement to the game. We identify three levels of player engagement, and find that all players are more likely to watch incentivized ads when in need of coins or have a lower nuisance cost. Challenge level of the game is helpful to motivate high and medium engagement players, but deters gamers with low engagement level from watching. On the other hand, low-engagement players are prone to view reward ads as their tenure increasing, while medium gamers reduce their tendency in this situation.

4 - **Artificial Intelligence and Human Intelligence - A Field Experiment Based on A College Application Assistance Program**

Xue (Jane) Tan, Indiana University, Kelley School of Business, Bloomington, IN, 47405, United States, janetan@iu.edu, Mochen Yang

This paper leverages an online platform that provides both artificial intelligence and human intelligence to aid high school graduates with college application. A unique field experiment was conducted to understand the complementarity of artificial and human intelligence. In a course of three days, messages were sent to students who used only one type of assistance. By examining students' response to the message, we observed interesting findings.

■ MD04

CC- Room 204

Data and Process Mining Meet Operations Research

Sponsored: Data Mining

Sponsored Session

Chair: Arik Senderovich

1 - **Globally-consistent Rule-based Summary-explanations for Machine Learning Models: Application to Credit-risk Evaluation**

Yaron Shaposhnik, University of Rochester, Simon Business School, Rochester, NY, 14627, United States, yaron.shaposhnik@simon.rochester.edu, Cynthia Rudin

We develop a method for interpreting specific predictions made by predictive models by constructing (local) models tailored to each specific observation. Unlike existing work that ``explain" specific observations by approximating global models in the vicinity of these observations, we fit models that are globally consistent with predictions made by the global model on past data. We focus on rule-based models and design multiple algorithms to extract such rules from discrete and continuous datasets. Finally, we apply these algorithms to a variety of credit-risk models trained on data from FICO and demonstrate that our approach produces sparse summary-explanations of these models.

2 - **Optimal Planning and Decision Making with Learned Neural Network Transition Models**

Buser Say, PhD Candidate, University of Toronto, Toronto, ON, M5T 1K2, Canada, buser.say@mail.utoronto.ca, Ga Wu, Scott Sanner

Hybrid Deep MILP Planning (HD-MILP-Plan) is a two-stage data-driven framework for learning and solving automated planning and decision making problems. Given samples of state transition data, the first stage of HD-MILP-Plan learns the transition function using a NN. In the second stage, the learned NN is sequentially chained over a horizon, and compiled into a MILP for optimal decision making. In this talk, a base MILP encoding and an improved MILP encoding based on additional preprocessing will be presented. Both models will be empirically evaluated on challenging benchmark instances.

3 - **Data Driven Forecasting and Revenue Management with Exposure Dependent Reference Prices**

Opher Baron, University of Toronto, Toronto, ON, M5S 1L7, Canada, opher.baron@rotman.utoronto.ca

We use data on the retail business of TMall to consider scalable implementation of revenue management (RM) in the presence of reference prices (RPs). We introduce forecast based upon RP with exposure effect and establish that these are more accurate than forecast ignoring this effect for many items. We develop scalable, data driven methodologies to compare the effectiveness of forecasts; demonstrate these methodologies; introduce models capturing exposure effect on RP via sales or clicks; and formulate and study RM when forecasts are RP-dependent. The improved accuracy and robustness of RM with forecast based upon RP with exposure effects support their usage in practice.

4 - **Process Performance Analysis Using Temporal Network Representations of Event Logs**

Matthias Weidlich, Professor, Humboldt University of Berlin, Berlin, Germany, matthias.weidlich@hu-berlin.de

Sojourn times and remaining times of business processes may be assessed based on event logs. Yet, existing work considers control-flow and performance information separately, or relies on an ad-hoc selection of temporal relations between events. In this work, we introduce the Temporal Network Representation (TNR) of a log. Based on Allen's intervals, it captures the pairwise temporal relations of activity executions. We demonstrate the usefulness of the TNR for detecting (unrecorded) delays and for probabilistic mining of variants in performance modelling. Our experiments with real-life healthcare datasets show that the TNR yields an up-to 40% improvement in sojourn time estimation.

5 - **Modeling Provider Learning Curves using Real-Time Locating System Data**

Arik Senderovich, Postdoctoral Fellow, University of Toronto, Toronto, ON, Canada, sariks@mie.utoronto.ca, Petar Momcilovic, Nikolaos Trichakis, Jillian Berry Jaeker

The implementation of electronic medical records (EMR) has been noted to disrupt clinical workflows as providers acclimate to a new EMR. On May 30, 2015, Dana-Farber Cancer Institute (DFCI) implemented a new EMR. Using our Real Time Location System (RTLS), we sought to identify the time required to stabilize the experience for providers. We identified factors that may speed the stabilization rate to guide EMR implementations elsewhere.

■ MD05

CC- Room 205

Advances in the Area of Business Analytics: Teaching & Research

Sponsored: Data Mining

Sponsored Session

Chair: Sinjini Mitra

1 - Improving Returns from Search Engine Marketing Using Google AdWords and Clustering – A Joint Teaching Effort between Data Sciences and Marketing Departments of Marshall School of Business

Arif Ansari, University of Southern California, Los Angeles, CA, 90089-0809, United States, aansari@usc.edu

Search Engine Marketing (SEM) is used by almost all major corporations and small companies are investing substantial portion of their marketing budget in SEM. Small companies lack the skills and man power of major corporations and they are looking for an edge over the competition. In this paper, we show how Data Science and Marketing department can collaborate and bring new and effective methods for small companies to compete against the major corporations. In this paper we will show how a small player can use Clustering and ROI based approach to compete with the major Resort in Bahamas and bring traffic to its website and sell their timeshare apartments to price sensitive customers.

2 - Business Analytics Education Lessons Learned from Program Development and Roll Out

Stephen Hill, University of North Carolina-Wilmington, 601 South College Road, Wilmington, NC, 28403-5611, United States, hills@uncw.edu

In this work we discuss various lessons learned from the development and roll out of Business Analytics programs at the undergraduate and graduate levels. We identify challenges faced, unexpected pitfalls, and ongoing issues and concerns.

3 - Transitioning From Administration Back to Faculty: A Journey Well Earned

Andrew Urbaczewski, United States Air Force Academy, Colorado Springs, CO, 80208, United States, andrew@urbaczewski.com

This session will detail the journey from a long-term administration position back to a research and teaching position. This presentation will cover preparation for and actual re-entering the world of university faculty.

4 - Experiment. Fail. Learn. Repeat.

Aaron Burciaga, Analytics2Go, Tysons, VA, 22102, United States, adburciaga@gmail.com

During this session, Aaron Burciaga CAP, Co-Founder and Principle of DataPrime, will share recent advances, new methods, emerging technologies, and research that facilitates speedier innovation and business impact though Analytics, Data Science, Machine Learning, and AI Engineering. Having developed Analytics Centers of Excellence for Fortune 100 Companies, growing and leading teams of over 400 data scientists, and being key advisor to government officials on the establishment of AI programs, Aaron will share what has made a difference across the hallmark projects that have revolutionized industry.

5 - Predictors of Choosing Business Analytics Concentration and Consequent Academic Performance

Sinjini Mitra, Associate Professor, California State University-Fullerton, ISDS Department, SGMH-4113, Fullerton, CA, 92831, United States, smitra@fullerton.edu, Zvi Goldstein, Bhushan Kapoor

In this talk, we present a comprehensive study of factors that affect students' choice of Business Analytics as the field of study via statistical and data mining techniques. Factors considered include personality traits including the "dark triad" and external factors such as interest or passion, lucrative job market, advice of faculty, experts and family, among others. Moreover, we also investigate which factors, particularly those related to personality traits, affect students' performance in this field, once selected.

■ MD06

CC- Room 209

Joint Session DM/Opt: Interplay between Machine Learning and Optimization.

Sponsored: Data Mining

Sponsored Session

Chair: Hari Bandi

Co-Chair: Hussein Hazimeh

1 - Statistical Hypothesis Testing via Robust Optimization

Hari Bandi, MIT, Cambridge, MA, 02139, United States, hbandi@mit.edu, Dimitris Bertsimas, Rahul Mazumder

In this work, we develop a novel framework for designing statistical hypothesis tests when given access to i.i.d. samples drawn under the considered hypothesis. We construct uncertainty sets for a testing sample using the Wasserstein distance with respect to the empirical distribution of the given sample. Using these uncertainty sets, we formulate a Sample Robust Optimization problem to design tests that maximally separate the two hypotheses using an affine combination of statistics. We prove the framework has finite and asymptotic optimality guarantees and show that it empirically performs better than existing hypothesis tests under distributional misspecification.

2 - Solving Large Scale Linear Programs in Machine Learning Tasks

Rahul Mazumder, Massachusetts Institute of Technology, Sloan School of Management, Cambridge, MA, 02139, United States

We consider a collection of problems popularly studied in Machine Learning and highdimensional statistics that can be cast as solutions to Linear Programs. In many modern applications these LP problems involve millions of decision variables and/or constraints—posing computational challenges. Examples include SVMs with L1 penalty, sorted L1 penalty, the Dantzig Selector, total variation denoising, etc. I wi Winchester, VA, ll describe how classical methods in large scale LP (e.g, column and constraint generation), when combined with approximate solutions available from surrogate problems (amenable to first order methods); can be surprisingly effective to solve these class of problems.

3 - Online Parameter Selection for Web-based Ranking via Bayesian Optimization

Kinjal Basu, Staff Software Engineer, LinkedIn Corporation, Sunnyvale, CA, United States, kbasu@linkedin.com, Deepak Agarwal, Souvik Ghosh, Ying Xuan, Yang Yang, Liang Zhang

Web-based ranking problems involve ordering different kinds of items to be displayed on a website or a mobile app. Usually, there are multiple conflicting objectives that we would want to balance. Constructing a serving algorithm that achieves the desired tradeoff is quite challenging. In this talk, we first show how we can model the balance criteria as a composite utility function over the space of control parameters in the ranking model. We then use Bayesian Optimization to obtain the optimal parameter values and illustrate its efficacy in the context of LinkedIn Feed. We show the effectiveness of our method by using both offline simulations as well as promising online A/B testing results.

4 - Multivariate Nonparametric Convex Regression: Algorithms and Theory

Wenyu Chen, Massachusetts Institute of Technology, Cambridge, MA, United States, wenyu@mit.edu, Rahul Mazumder

In general, nonparametric convex regression allows for more flexibility in modeling compared to multiple linear regression. It is an important model in econometrics, machine learning and operations research with many applications, such as fitting concave utility functions and giving convex approximation of a function. However, the nonparametric convex regression problem, written as the solution to a quadratic program with O(n2) linear constraints (n being the sample size), is difficult to solve and does not scale well. We develop an algorithm with provable linear convergence, and it can scale to $n \approx 50{,}000$.

■ MD07

CC- Room 210

Joint Session DM/Practice Curated: Inter-Disciplinary Topics Related to Data Mining: Lessons and Examples

Sponsored: Data Mining

Sponsored Session

Chair: Christopher Grubb

1 - Embedding Open Source NLP Tools in Production Systems

Emily Bicks, Deloitte Consulting, Arlington, VA, United States, embicks@deloitte.com

It's getting easier and easier to build open-source machine learning models to understand natural language. But generally these models can't easily be integrated into enterprise systems. This presentation showcases how Deloitte is integrating a supervised text categorization model trained on millions of records into an enterprise email system at a large federal agency. We will present details of our approach, which converts the machine learning pipeline into ONNX and embeds it into the .NET framework production system.

2 - Assisting Federal Agencies Declutter Search Results through Content Type Metadata Tagging

Isaac Stevens, Deloitte, Arlington, VA, United States, isstevens@deloitte.com

In order to assist a large federal agency in handling their high volume of Freedom of Information Act (FOIA) requests, a text categorization, semi-supervised learning model was implemented to identify and tag non-relevant news emails, allowing analysts to filter out these emails from search and analysis. Because keywords in FOIA requests often parallel closely with current events, filtering out these news updates greatly reduces search time for FOIA analysts looking for records pertinent to requests. This presentation discusses the business impact of using open-source NLP tools for content filtering.

3 - Fundamental Equilibrium Models for Commodity Markets

Jai Gopal, Specialist Leader, Deloitte, Los Angeles, CA, United States, jagopal@deloitte.com

MarketBuilder (MB) is a software system used to build fundamental, dynamic, microeconomic market models and calculate market clearing prices and quantities combining supply, transportation, demand, and other key economic constructs in a spatial market network. MB simulates goal-seeking behavior in the market. MB can be used to answer key business questions, strategies, consumption and depletion of competing resources, mark to market existing flow/capacity, asses market risks and support trading and arbitrage activities. MB is based on a graphical nodal network for solving nonlinear supply and demand curves in time-dependent, spatially diverse networks.

4 - Presenter

Ande Barry, Data Scientist, Deloitte Consulting, Washington, DC, United States

Positive-unlabeled (PU) learning addresses the concern of training binary classifiers on data that is either positive (P) or unlabeled (U). In these situations, negative data (N) can become nearly impossible to label, or gathering an abstract sample set of only PU data is significantly easier by comparison. This talk will discuss an approach to using positive-unlabeled data in training a text classification machine learning algorithm by using two step sample expansion techniques with python's Scikit-Learn package. As well, potential and past use cases of this method will be illustrated.

5 - Strategies for the Database Record Linkage Problem

Christopher C. Grubb, Grubb, Fairfax, VA, 22030, United States, chrisgrubb@me.com

Integration of data across databases and tables is often complicated by a lack of unique identifiers that are common across databases and tables. These 'record linkage problems' can be partially solved using methods that classify pairs of records as likely matches, unlikely matches, or as pairs that require human reviews. This presentation reviews heuristics and machine learning methods applicable to record-linkage problems that use text strings as comparison features between records. Performance comparisons (including algorithm runtime and classification/misclassification metrics) are included.

■ MD08

CC- Room 211

Joint Session AI & ML/Practice Curated: Fairness and Bias in AI/ML

Emerging Topic: Artificial Intelligence & Machine Learning

Emerging Topic Session

Chair: Swati Gupta, Georgia Institute of Technology, Atlanta, GA, 30332, United States

Chair: Vijay Kamble, University of Illinois at Chicago, Chicago, IL, 60611, United States

1 - On Preserving Non-discrimination When Combining Expert Advice

Thodoris Lykouris, PhD Candidate, Cornell University, Ithaca, NY, 14853, United States, teddlyk@cs.cornell.edu, Avrim Blum, Suriya Gunasekar, Nathan Srebro

Understanding the trade-offs involved in optimizing performance and avoiding discrimination against protected groups is essential to inform societally responsible decision-making. Aiming to understand the effect of adaptivity on this tug-of-war, we focus on sequential decision making when samples arrive online and do not follow distributional assumptions. We address the most basic extension of classical online learning that takes into account the goal of non-discrimination: "Given a class of predictors that are individually non-discriminatory (with respect to a particular metric), how can we combine them to perform as well as the best predictor, while preserving non-discrimination?".

2 - An Information Theoretic Look at Fair Machine Learning

Flavio P. Calmon, Harvard University, Cambridge, MA, United States, flavio@seas.harvard.edu

Machine learning (ML) algorithms are at risk of inheriting and reinforcing social biases and discrimination patterns present in the training data, which may reflect discrimination patterns existent in society at large. In this talk, we present a few information-theoretic results that build on rate-distortion theory and estimation theory to characterize the fundamental accuracy cost of ensuring fairness in ML. We delineate a few fundamental limits of non-discrimination in classification by studying fairness-constrained estimators. This approach informs a practical and scalable method for training fair classifiers. Work done jointly with Hao Wang, Shahab Asoodeh, and Wael Alghamdi.

3 - Delayed Impact of Actions in Multi-armed Bandit

Yang Liu, University of California, Santa Cruz, CA, United States, yangliu@ucsc.edu

Algorithms have been increasingly involved in decision making in our daily life. Oftentimes these decisions have influences on the subsequent rewards and in turn invalidate the assumption. For example, the capability to pay back a loan for people in a certain group might depend on historically how frequently that group has been approved a loan application. If banks keep rejecting loan applications to most people in a disadvantage group, it could create a feedback loop and further damage the chance of getting loans for people in that group. We study the impacts of actions in the multi-armed bandit framework, the classical sequential decision making framework that is particularly suitable for our study.

4 - On the Compatibility of Privacy and Fairness

Rachel Cummings, Georgia Tech, Atlanta, GA, 30332-0205, United States, Varun Gupta, Dhamma Kimpara, Jamie Morgenstern

In this work, we investigate whether differential privacy and fairness can be simultaneously achieved by a single classifier, using statistical notions of fairness, namely Equality of False Positives and Equality of False Negatives (EFP/EFN). We show that even under full distributional access, the constraint of differential privacy can preclude exact EFP/EFN. We then show the existence of a PAC learner which is differentially private and approximately fair (EFP/EFN) with high probability. Finally, we give an efficient algorithm for classification that maintains utility and satisfies both privacy and approximate fairness with high probability.

■ MD09

CC- Room 212

Heterogeneous Data Analytics

Sponsored: Artificial Intelligence

Sponsored Session

Chair: Hongfu Liu

1 - Goal-based Recommendation

Weijie Jiang, PhD, Tsinghua University, Beijing, China, jiangwj.14@sem.tsinghua.edu.cn, Qiang Wei, Zachary Pardos

Learners are often faced with the scenario: given a goal for the future, and what they have learned in the past, what should they do now to best achieve their goal? We utilize deep learning to make inferences about how past actions correspond to future outcomes. We apply this technique to datasets both from a university setting in which courses can be recommended towards preparation for a target course, and from MOOCs in which course pages can be recommended towards quiz preparation. The proposed algorithm is applied to recommend actions the learner can take to maximize a desired future achievement objective.

2 - Recurrent Neural Networks for Cross-domain User Modeling

Sheng Li, University of Georgia, Athens, GA, United States

Understanding and predicting user behavior is critical for providing seamless user experiences as well as increasing revenue of service providers. Recently, thanks to the remarkable success of recurrent neural networks (RNNs), it has been widely employed for modeling user behaviors from sequential data. In this talk, I will introduce our recent work on RNNs based cross-domain user modeling. First, we introduce a practical domain switch problem, and propose a holistic recurrent neural network approach. Second, we leverage auxiliary unstructured log-trace data and propose a recurrent semantics memory network for user modeling. Future research directions on this topic will be discussed as well.

3 - Explainable recommendation with attribute network

Guannan Liu, Beihang University

Please check the mobile app for this abstract.

4 - Bullet Screen Assisted Video Analysis

Hongfu Liu, Brandeis University, Waltham, MA, United States

Bullet screen surges as a new form of video comments, which enables the audience to interact with the video contents, and gradually becomes the crucial component of videos. Although bullet screen has drawn more and more attention in the real-world scenarios, the related research is still in the void stage. In this project, we aim to explore the rich information of the bullet screen for video analysis. Specifically, we will focus on the sentiment and mine the relationship between bullet screen and static comments.

■ MD10

CC- Room 213

Joint Session Analytics/Practice Curated: People Analytics

Sponsored: Analytics

Sponsored Session

Chair: Margret V. Bjarnadottir, Reykjavik, 112, Iceland

Co-Chair: David Anderson, CUNY Baruch, Hoboken, NJ, 07030, United States

1 - The Role of Operations Research in Revolutionizing the Human Resource Department

Margret V. Bjarnadottir, University of Maryland, College Park, MD, 112, United States, margret@rhsmith.umd.edu, David Anderson

Analytics are changing all aspects of business - including the HR department. In this talk we discuss the role of, and the opportunity for Operations Research methodology in human resource management. We provide an overview of the development of People Analytics and future research opportunities.

2 - Addressing the Gender Pay Gap in Practice

David Anderson, Villanova School of Business, Villanova, PA, 07030, United States, David.Anderson@Villanova.edu, Margret V. Bjarnadottir

Companies are facing increasing pressure from employees, shareholders, and customers to measure and address gender pay gaps. In this paper, we discuss how employers can take steps to close gender pay gaps as fairly as possible at as low of a cost as possible. We discuss the policy implications and unintended consequences of focusing on the "unexplained" pay gap, as currently measured, using regression analysis. We further discuss different methods of measuring pay gaps specifically, and gender equality more generally across an organization, and the varying pressures that different regulations place on employers.

3 - A Multi-stage Model for High-volume Recruitment

Qing Li, Hong Kong University of Science & Technology, Dept. of ISOM, Clear Water Bay, Kowloon, Hong Kong, imqli@ust.hk, Lilun Du, Peiwen Yu

The process to recruit a total of n workers consists of multiple stages, each of which corresponds to an application deadline. The qualification of applicants is known only after they have submitted their applications. The offer acceptance yield is random, and it is undesirable if the total yield in the end is different from n. What is the optimal number of offers given in each stage? We formulate the problem as a Markov Decision Process, explore its convergence properties when n and the number of applicants in each stage are large, and test it with a data set.

■ MD11

CC- Room 214

Markov Lecture

Sponsored: Applied Probability

Sponsored Session

Chair: Rami Atar, Technion, Haifa, 32000, Israel

1 - Finding Structures Planted in Random Graphs

Laurent Massoulié, Inria, Paris, France

The problem of finding structures planted in otherwise random graphs arises in many applications and gives rise to rich mathematical phenomena: By varying the strength of the planted signal, the problem may go from feasible to infeasible (an information-theoretic phase transition), and from polytime-feasible to polytime-infeasible (a computational phase transition). In this lecture we will cover results of this kind first for planted structures consisting in a planted partition, for which we will describe efficient spectral algorithms. We will then discuss phase transitions for detection and reconstruction of structures consisting in a planted tree graph.

2 - Efficient Random Graph Matching: Algorithms and Theory

Jiaming Xu, Duke University, Durham, NC, 47907, United States, jiaming.xu868@duke.edu

Random graph matching refers to recovering the underlying vertex correspondence between two random graphs with correlated edges. It offers a rich set of problems involving the interplay of optimization, random matrix theory, and information theory. This talk will present an overview and our recent results on this topic.

3 - Discussant

Bruce Hajek, University of Illinois, CSL, 1308 W. Main Street, Urbana, IL, 61801, United States

Extensions of community detection beyond the stochastic block model will be discussed.

■ MD12

CC- Room 2A

Bandits, Reinforcement Learning, and Causal Inference

Sponsored: Applied Probability

Sponsored Session

Chair: Shipra Agrawal, Columbia University, New York, NY, 10027, United States

1 - Recent Advances and Challenges in Counterfactual Learning for Long-Term Decision Making

Adith Swaminathan, Microsoft, Redmond, WA, 98052, United States

Off-Policy Reinforcement Learning offers a useful framework for counterfactual reasoning when re-using the logs of an interactive system to train new policies to engage with users. We will describe recent work (with Yao Liu, Alekh Agarwal and Emma Brunskill; https://arxiv.org/abs/1904.08473, UAI'19) that describes a new class of off-policy estimators that work well for these temporally-extended interaction settings and demonstrates successful off-policy policy optimization. We will conclude by sketching three open problems in learning from logged interaction data.

2 - Smooth Contextual Bandits: Bridging the Parametric and Nonparametric Regret Regimes

Nathan Kallus, Cornell University, New York, NY, 1004 4, United States, kallus@cornell.edu, Yichun Hu, Xiaojie Mao

We study a non-parametric contextual bandit problem where the arms are Holder functions with smoothness parameter β. We show how this interpolates between two extremes that were previously studied in separation: non-differentiable bandits ($\beta\leq1$) and parametric bandits ($\beta\to\infty$). We develop a novel algorithm that carefully adjusts to all smoothness settings and achieves rate-optimal regret in either extreme as well as in between. In this sense, our results bridge the gaps both between the existing literatures on parametric and non-parametric contextual bandits and between bandit algorithms that leverage global and local reward information.

3 - Discussion

Shipra Agrawal, Columbia University, Industrial Engnr and OR, 423 S. W. Mudd Building, New York, NY, 10027, United States

In this talk the session chair will lead a discussion on the work presented in this session.

■ MD13

CC- Room 2B

Load Balancing, Routing and Caching in Networks and Data Centers

Sponsored: Applied Probability

Sponsored Session

Chair: Siva Theja Maguluri, ISyE Ba Tech, Atlanta, GA, 30339, United States

1 - Achieving Zero Queueing Delay for Parallel Jobs

Weina Wang, Carnegie Mellon University, Pittsburgh, PA, 15213, United States

Zero queueing delay is highly desirable in large-scale load-balancing systems. Existing work has shown that it can be asymptotically achieved by using the celebrated power-of-d-choices policy with a probe ratio d = omega(1/(1-lambda), and it is impossible when d = O(1/(1-lambda)), where lambda is the load of the system. In this work, motivated by the predominant use of parallel computing, we study the model where each job consists of a batch of k parallel tasks. We show that in this model, zero queueing delay can be achieved with a probe ratio d = omega(1/((1-lambda)log(k)), which is smaller than the lower bound in the non-parallel model.

2 - Optimal Service Elasticity in Large Scale Distributed Systems

Debankur Mukherjee, Georgia Institute of Technology, Atlanta, GA, 02109, United States, debankur.mukherjee@isye.gatech.edu, Sem C. Borst, Souvik Dhara, Johan S.H. van Leeuwaarden, Aleksandr Stolyar

A fundamental challenge in large-scale systems is to achieve efficient server utilization and limit energy consumption, while providing excellent performance. We propose a joint auto-scaling and load balancing scheme, which does not require any global queue length info or explicit knowledge of system parameters, and yet provides near-optimal service elasticity. Specifically, we prove that both the waiting time of tasks and the relative energy consumed by idle servers vanish in the limit. At the same time, the scheme operates in a distributed fashion and involves only constant communication overhead per task, ensuring scalability in massive data center operations.

3 - Heavy-traffic Delay Optimality in Pull-based Load Balancing Systems: Necessary and Sufficient Conditions

Xingyu Zhou, The Ohio State University, Columbus, OH, United States, Jian Tan, Ness Shroff

In this talk, we consider a load balancing system under a general pull-based policy. In particular, each arrival is randomly dispatched to one of the servers with queue length below a threshold; if none exists, the arrival is randomly dispatched to one of the entire set of servers. We are interested in the fundamental relationship between the threshold and the delay performance in heavy traffic. To this end, we establish both necessary and sufficient conditions on the threshold for delay optimality in heavy traffic. In particular, the sufficient condition (i.e., a logarithmic growth rate of the threshold) resolves a long-standing open conjecture by Kelly and Laws.

4 - How to Achieve Delay Reduction with Near-zero Cache?

Fei Wu, The Ohio State University, Columbus, OH, United States, Ness Shroff

The fundamental challenge in achieving multicast gains is that although popular contents may be requested by multiple users, users may request popular contents at different times. In this work, we ask the following question: Can we achieve performance improvement even with very limited cache space? We develop a new analytical framework such that the asymptotic delay performance can be characterized given a load-adaptive caching and scheduling policy in the heavy-traffic regime. We show that even when the cache size is asymptotically zero in the heavy-traffic regime, predictive caching could achieve a significant delay reduction, compared with the optimal policies without predictive caching.

■ MD14

CC- Room 302

Student Paper Competition II

Sponsored: Manufacturing & Service Oper Mgmt

Sponsored Session

Chair: Feryal Erhun, University of Cambridge, Trumpington Street, Cambridge, CB2 1AG, United Kingdom

Co-Chair: Yi Xu, University of Maryland, DO & IT Department, Smith School of Business, College Park, MD, 20742, United States

Chair: Antonio Moreno, Harvard Business School, Morgan Hall 494, Boston, MA, 02163, United States

1 - Timely After-Sales Service and Technology Adoption: Evidence from the Off-Grid Solar Market in Uganda

Amrita Kundu, London Business School, Regent’s Park, PhD Office - MSO, London, NW1 4SA, United Kingdom, Kamalini Ramdas

In this paper, we examine to what extent timely after-sales service impacts technology adoption in emerging markets. Using detailed customer-level sales and service data from a leading solar distribution company operating in Uganda, we develop a fixed effects base specification and two geo-spatially based instrumental variables specifications. We find that timely after-sales service experienced by existing customers is a strong driver of purchase by first-time users. Further, the number of customers acquired through referrals from an existing customer depends on the referring customer’s service wait time. This provides evidence of a strong word-of-mouth channel of information sharing.

2 - Can Big Data Cure Risk Selection in Healthcare Capitation Programs?

Zhaowei She, Georgia Institute of Technology, Atlanta, GA, United States, Turgay Ayer, Daniel Montanera

We analyze the risk selection problem in Medicare Advantage (MA), the largest capitation payment program in the U.S. healthcare market. In practice and current literature, the observed risk selection in MA is primarily attributed to data limitations and low explanatory power (e.g. low R^2) of the current risk adjustment design. However, our study shows that MA cannot eliminate risk selection even if its risk adjustment design becomes informationally perfect (e.g. R^2 =1) in the age of big data. To address risk selection in capitation programs, payers should not solely rely on big data and advanced ML algorithms, but need to consider mechanisms other than pure statistical risk adjustment designs.

3 - Dynamic Learning and Pricing with Model Misspecification

Milashini Nambiar, Massachusetts Institute of Technology, Cambridge, MA, 02142, United States, David Simchi-Levi, He Wang

We study a multi-period dynamic pricing problem where demand depends on time-varying contextual information. We are especially interested in demand model misspecification and show that it can cause inconsistent price elasticity estimates and suboptimal pricing decisions. We thus propose a “random price shock” (RPS) algorithm that estimates price elasticity by dynamically generating randomized price shocks. RPS has strong theoretical performance guarantees, and offline simulations on a fashion retail dataset demonstrate average revenue gains of 8-20% over competing algorithms.

■ MD15

CC- Room 303

NSF

Emerging Topic: NSF

Emerging Topic Session

Chair: Jeff Cohen, INFORMS, Catonsville, MD, 21228, United States, jeff.cohen@informs.org

Co-Chair: Sheldon H. Jacobson, University of Illinois, Dept of Computer Science, Urbana, IL, 61801-2302, United States

1 - An Overview of Computing Research at the National Science Foundation

(Walter) Rance Cleaveland, Computing and Communication Foundations (CISE/CCF), Alexandria, VA, United States

In this talk I will give an overview of the Computing and Information Science and Engineering (CISE) directorate at the National Science Foundation. Through CISE NSF provides over 85% of federal funding for basic computing research. I will briefly outline how CISE is organized and then spend time describing the research activities in the CCF and Intelligent Information Systems (IIS) divisions of CISE, which are where topics of most interest to the INFORMS community are most likely to find support.

■ MD16

CC- Room 304

Modeling and Management of Service Systems

Sponsored: Manufacturing & Service Oper. Mgmt/Service Operations

Sponsored Session

Chair: Carri Chan, Columbia Business School, New York, NY, 10027, United States

Chair: Jing Dong, Columbia University, New York, NY, 60208, United States

1 - Dynamic Learning and Rational Customers in Services

Nur Sunar, UNC, 1604 Village Crossing Drive, Chapel Hill, NC, 27517, United States, nur_sunar@kenan-flagler.unc.edu, Yichen Tu, Serhan Ziya

We consider a single-server queueing system where customers make joining and abandonment decisions when a service characteristic is unknown. We study different ways in which customers process service-related information, and how these impact the performance of a service provider. Specifically, we analyze forward-looking, myopic and naïve information processing behaviors by customers. There is a rich literature that establishes that forward-looking customers are detrimental to a firm in settings different than queueing. In contrast to this common understanding, we prove that for service systems, forward-looking customers are beneficial to the firm under certain conditions.

2 - Hospital Readmissions Reduction Program Does Not Provide the Right Incentives: Issues and Remedies

Kenan Arifoglu, UCL, London, United Kingdom, k.arifoglu@ucl.ac.uk, Hang Ren, Tolga Tezcan

The Hospital Readmissions Reduction Program (HRRP) reduces Medicare payments to hospitals with higher-than-expected readmission rates. HRRP has three distinct features, i.e., multiplier, capped penalty, and no-bonus payment. We use a principal-agent model to understand the impact of each of these features and show that: (i) HRRP over-penalizes hospitals with excess readmissions because of the multiplier; (ii) having a penalty cap can curtail the effect of financial incentives and result in a no-equilibrium outcome when the cap is too low; and (iii) not allowing bonus payment leads to many alternative symmetric equilibria, including one where hospitals exert no effort to reduce readmissions.

3 - Spatial Pricing: An Empirical Analysis of Taxi Rides in New York City

Nasser Barjesteh, University of Chicago, Chicago, IL, United States, barjesteh@chicagobooth.edu, Baris Ata, Sunil Kumar

We study how spatial pricing and search friction can impact the taxi market in NYC. We use a mean field model, in which taxi drivers strategically search for customers, taking into account the spatial and temporal distribution of supply and demand as well as the spatial prices. Our model captures the interplay between spatial pricing and search friction. Spatial pricing can incentivize relocation of taxis to a neighborhood while the use of mobile applications can alleviate search friction within that neighborhood. We fit our model to a dataset of taxi rides over four years and conduct counterfactual studies to explore how spatial pricing impacts supply, demand, consumer welfare, and drivers' profit.

4 - Optimal Scheduling of Proactive Care with Patient Deterioration

Yue Hu, Columbia Business School, New York, NY, United States, YHu22@gsb.columbia.edu, Carri Chan, Jing Dong

Healthcare is a limited resource environment where the most severe patients are typically prioritized. However, there has been a growing interest in preventative care. While providing care for patients when they are less critical could mean that fewer resources are necessary to return them to a healthy state, utilizing limited capacity for patients who may never need it also takes the capacity away from other more critical patients. To understand this tension, we propose a two-class queueing model where a moderate class patient who does not receive treatment may recover or deteriorate to an urgent class. In this setting, we characterize how moderate and urgent patients should be prioritized for care.

■ MD17

CC- Room 305

Design of Marketplaces

Sponsored: Manufacturing & Service Oper. Mgmt/Service Operations

Sponsored Session

Chair: Yash Kanoria, Columbia University “

Co-Chair: Fanyin Zheng, Columbia University, New York, NY, 10027, United States

1 - User Privacy in Platforms

Ruslan Momot, HEC Paris, 1 Rue de la Liberation, Jouy-en-Josas, 78350, France, momot@hec.fr, Itay Fainmesser, Andrea Galeotti

We build an equilibrium model of platform privacy. The users experience direct utility from using the platform, however, they are also susceptible to strategic self-interested, criminals who use the information users put on the platform. The platform, in turn, chooses the amount of data it stores and shares with business partners, and its security level. We characterize the equilibrium activity levels of users and criminals, and the resulting privacy levels, as well as how these are affected by different attributes of the platforms, such as the strength of network effects. We also investigate the extent to which a competition among platforms might affect equilibrium privacy levels.

2 - A Risk-ratio Procedure for Consumer Choice-based Demand Estimation for Sales Transaction Data

Anran Li, London School of Economics and Political Science, Department of Management, New Academic Building, LSE, London, WC2A 2AE, United Kingdom, A.Li26@lse.ac.uk, Kalyan Talluri

We consider the estimation problem for a retailer who sells an assortment of products but records only sales transactions; i.e., the no-purchased alternative is never observed. Consumer choice is captured by the Multinomial logit discrete choice model. Out goal is jointly estimating arrival rate and the choice model parameters from sales transaction data without observing no-purchases. We propose a Two-Step estimation approach. Comparing with all the existing methods in the literature, our algorithm requires least amount of information. Moreover, in extensive numerical testing and comparison we find that our method is most robust, especially when the assortments are endogenized.

3 - Recommender Systems on Platforms

Renyu Zhang, New York University Shanghai, Shanghai, 200122, China, renyu.zhang@nyu.edu, Xuan Wang, Dennis Zhang

We study how a recommender system could match the demand and supply of a two-sided platform, which seeks to maximize the weighted number of transactions between consumers and producers. The traditional recommender system has been focusing on identifying and recommending the producers of the highest qualities. Albeit optimal when producers have unlimited capacities, such a recommender system may result in substantial optimality losses in the presence of producer capacity constraints and producer quality evolution, especially when the demand and supply are balanced.

4 - Optimizing Assortment Size and Variety in Online Platforms

Abhinav Sinha, Postdoctoral Researcher, Columbia University, New York, NY, 10027, United States, as5561@columbia.edu, Yash Kanoria, Fanyin Zheng, Zhenyu Lai

Many online marketplaces face the challenge of determining the right assortment size and variety. Using data from a large online e-retailer of diverse home goods, we develop a systematic structural estimation approach to estimate a discrete choice model of customer purchase behavior that also incorporates choice paralysis that customers may face on a platform with too many products. We quantify the causal impact of assortment size and product variety on likelihood of purchase and use the estimated model to infer the optimal assortment size and product variety for each category on the platform. Finally, we design and run an experiment to validate our estimated model, its predicted counterfactuals.

■ MD18

CC- Room 306

Environmental, Economic and Social Issues in Supply Chain

Sponsored: Manufacturing & Service Oper. Mgmt/Supply Chain

Sponsored Session

Chair: Greys Sosic, University of Southern California, Los Angeles, CA, 90089-0809, United States

Co-Chair: Hailong Cui, University of Southern California, Los Angeles, CA, 90089-0809, United States

1 - The Environmental Impact of the Advent of Online Grocery Retailing

Ekaterina Astashkina, INSEAD, Boulevard de Constance, Fontainebleau, 77305, France, ekaterina.astashkina@insead.edu, Elena Belavina, Simone Marinesi

To study the environmental impact of the advent of online grocery retailing, we build a stylized 3-tier model of geographically-dispersed traditional and online fresh grocery retail chains. We analytically compare food waste and transportation emissions before & after the advent of online grocery retail. We isolate three key factors that drive the difference: (i) which households switch to online shopping, (ii) their shopping patterns, and (iii) how the first two factors change where inventories are held. Numerical calibration using industry and demographic data reveals that in most US cities the advent of online grocery should be beneficial, leading to an eventual 8-41% reduction in emissions.

2 - The Resilience of Airline Networks to Severe Weather

Beverly Osborn, The Ohio State University, Columbus, OH, United States, osborn.259@osu.edu, Hyunwoo Park, Christian Blanco

Climate change can negatively impact the airline industry. We empirically study the relationship between airline network structure and the impact of severe weather events using data from the Bureau of Transportation Statistics from 2003-2017. We measure network concentration using the Herfindahl-Hirschman Index and compare the propagation of delays between different networks.

3 - Donor Funding for Drug Availability

Iva Rashkova, Washington University in St Louis, St. Louis, MO, United States, irashkova@wustl.edu

We study the decision of a donor subsidizing health programs in a developing country by allocating a fixed procurement budget between the public and private distribution channels. The donor's objective is to maximize consumption and funding can be a lump-sum disbursement to the public channel, per-unit subsidy to the private channel, or both. We show that that the two types of funding exhibit a risk-hedging synergy. Using real data from 48 African countries, we show that expected consumption could be improved by up to 24% if the budgets were reallocated to take advantage of this synergy.

4 - Rebound Effects under Manufacturer's Intervention into Secondary Market

Hailong Cui, University of Southern California, Marshall School of Business, Data Sciences and Operations, Los Angeles, CA, 90089-0809, United States, HailongC@marshall.usc.edu, Greys Sosic

We study the manufacturer's intervention in the used product market. Specifically, the manufacturer purchases used products from consumers in the form of trade-in, then refurbishes such products and resells them to consumers. We study the optimal pricing, quality of refurbishing, and the implications on firm's profit and consumer welfare.

■ MD19

CC- Room 307

Emerging Topics in Operations Management

Sponsored: Manufacturing & Service Oper. Mgmt/Supply Chain
Sponsored Session

Chair: Rachel Rong Chen, University of California-Davis, Davis, CA, 95616, United States

Co-Chair: Shuya Yin, University of California-Irvine, Irvine, CA, 92697-3125, United States

1 - Service Provision in Distribution Channels

Haresh B. Gurnani, Wake Forest University, Winston Salem, NC, 27106, United States, gurnanih@wfu.edu, Shubhranshu Singh, Sammi Tang, Huaqing Wang

Consumers may need help using an inherently complex or information-intensive product after purchase. This paper studies the incentive for a manufacturer or a retailer to invest in pre-sales service effort that would reduce the consumer's likelihood of seeking after-sales support. Because providing pre-sales and after-sales support would incur costs for the provider, it is not evident whether the manufacturer or the retailer would be more effective in doing so, and whether both services should be provided by the same firm.

2 - Data-driven Menu Recommendation System of Meal-kit Services Using Machine Learning

Aysun Mutlu, McGill University, Montreal, QC, H2X2B7, Canada, aysun.mutlu@mail.mcgill.ca, Mehmet Gumus, Saibal Ray

Meal-kit services are a rapidly growing area in the food sector. This study empirically analyses recipe popularity in this sector from various perspectives of a particular meal-kit service provider. Main approaches exploited in the study are text and data analysis for relabeling, customer segmentation and recipe categorization. This study forms the backbone of building an improved menu recommendation system for the provider.

3 - A Model for Value Co-Creation with Multi-Producer Bundles

Hemant Bhargava, University of California, Davis, CA, United States, hemantb@ucdavis.edu

In many markets (e.g., in-home video entertainment), value is co-created by multiple producers and their outputs sold as a common bundle by a producer-consortium or a retailer. This paper develops an economic model to study demand, production, and revenue-sharing in such markets and examines market dynamics covering both the causes and effects of changes in industry structure.

4 - Membership Design for Subscription-based Retailing

Yiwei Wang, University of California-Irvine, Paul Merage School of Business, Irvine, CA, 92617, United States, willwangyiwei@gmail.com, Jeannette Song

An innovative trend, called subscription-based retailing (selling access of physical product, to members for a fixed fee) has gained increasing popularity. In this paper, we partner with Y-Closet, a leading fashion subscription provider, to explore the optimal design of membership structure under such business model. Our paper was motivated by real life observations and data analysis, and has both theoretical and practical impact.

■ MD21

CC- Room 309

iFORM SIG

Sponsored: Manufacturing & Service Oper. Mgmt/iFORM
Sponsored Session

Chair: Gangshu Cai, Santa Clara University, Santa Clara, CA, 95053, United States

1 - A New Firm Entry under Capital Constraint

Wenhui Zhao, Shanghai Jiao Tong University, 1954 Huashan Road, Shanghai, 200030, China, Guanmei Liu, Xuan Zhao

We study whether and how an entrant can enter a product market and compete with a dominant incumbent, when they both are capital constrained and need to borrow loans from a credit market. In the case that the credit market is monopolistic, the bank may reject the entrant's loan request, or "deter" her entry by providing the incumbent a lower interest rate. While a competitive credit market may favor a weak entrant, we show that a monopolistic credit market welcomes a strong entrant. Finally, we provide insights for the entrant on how to prepare working capital under a monopolistic credit market.

2 - The Effects of Stock-based Incentives on Inventory Management

Qi Wu, Case Western Reserve University, Cleveland, OH, 44122, United States, qxw132@case.edu, Guoming Lai

We develop a stylized model which shows that in the presence of an interest in the stock price, managers overinstall inventory when it can either inflate the sales or deflate the reported cost of goods sold (COGS) even if the market anticipates such actions. We analyze the joint as well as the marginal effect of stock-based incentives and the costs of using inventory to manage earnings, which may provide useful implications for the detection of inventory distortion and the design of management incentive plans. We then conduct an empirical analysis based on the financial data of the U.S. listed retailers and manufacturers.

3 - Strategic Financing and Information Revelation Amid Market Competition

Xinyi Zhao, Stern School of Business, New York University, 44 West 4 Street, New York, NY, 10012, United States, xzhao@stern.nyu.edu, Guoming Lai, Wenqiang Xiao

Under information asymmetry, a firm in financial need may have an incentive to either over-borrow or under-borrow due to financing effect and competition effect. We investigate the determinants of a firm's financing and information revelation strategy. First, under public financing, we discover that firm's decision is driven by its internal capital level and the market competition intensity. There exists a unique separating PBE under three regimes and the two averse incentives can be neutralized with some counter-intuitive results. Second, we find out the unique PBE under private financing. Last, we compare private financing with public financing and examine the equilibrium outcome.

4 - E-commerce Platform Finance for Small and Medium-sized Enterprises with Dual-channel

Xun Xu, California State University, Stanislaus, California State University-Stanislaus, One University Circle, Turlock, CA, 95382, United States, xxu@csustan.edu, Nina Yan, Zhineng Chen, Xiuli He

Through a game theoretical approach, taking consumers' channel preference into consideration, this study examines the supplier's optimal supply quantity for each channel and e-commerce platform's optimal interest rate and loan limit. We examine this in four scenarios based on supplier's financing needs and e-commerce platform's financing offering. We find supplier's channel strategy depends on her financial constraints, loans offered by platform, the channel's profit margin, and consumers' channel preferences. This study proves the value-added effect of e-commerce's financing service and provides important implications for supplier's distribution channel strategies.

■ MD22

CC- Room 310

Empirical Sustainable Operations

Sponsored: Manufacturing & Service Oper. Mgmt/Sustainable Operations
Sponsored Session

Chair: Christian Blanco, University of California-Los Angeles, Columbus, OH, 43210, United States

1 - Inclusive Manufacturing: Maximizing Disability Diversity, Cultural Diversity and Productivity

Ying (Maggie) Zhang, Clemson University, Clemson, SC, United States, ying6@clemson.edu, Sriram Narayanan, Kalyanmoy Deb, Tharo Soun

In this study, the impact of employing individuals with disabilities in garment manufacturing cells on overall team productivity was examined. Specifically, a multi-objective assignment problem with precedence and skill constraints was used to optimize productivity, disability diversity and cultural diversity across multiple garment types that vary in complexity levels. The analysis sheds light on how firms can employ people with disabilities in their organizations, and realize superior productivity. The results are stable and replicable across multiple garments the firm manufactures.

2 - Extended Producer Responsibility and Supplier Selection

Yuqi Peng, University of South Carolina, Columbia, SC, United States, Yuqi.Peng@grad.moore.sc.edu, Yan Dong

With the increasing public consciousness of product recycling and waste management, firms are encouraged or required to take the responsibility of end-of-life products, a.k.a extended producer responsibility (EPR). However, implementing EPR initiatives such as take-back or E-waste reduction is costly and requires coordination in a supply chain. We consider that EPR initiatives may play an important role in a focal firm's supplier selection decision. In this study, we empirically test if a firm's EPR initiatives affect the likelihood to be chosen as a supplier.

3 - Consistent Allocation of Emission Responsibility in Energy Supply Chains

Sanjith Gopalakrishnan, University of British Columbia, Vancouver, BC, Canada, sanjith.gopalakrishnan@sauder.ubc.ca, Daniel Granot, Frieda Granot

Canada's federal government, since 2016, factors in upstream emissions during the environmental impact assessment of energy projects. Motivated by the regulation, we adopt a cooperative game model and propose the nucleolus as a mechanism to apportion upstream emissions. It avoids the distortionary effects of double counting and exhibits a consistency property that is significant in a context wherein energy supply chains span multiple legal jurisdictions. We develop a polynomial time algorithm and further derive it as the unique subgame perfect equilibrium to a non-cooperative game induced by two easily stated and verifiable policies thereby lending a self-implementing policy framework.

4 - Does Environmental Performance Predict Quality Performance at FDA-regulated Plants?

In Joon Noh, Ohio State University, Columbus, OH, United States, noh.69@buckeyemail.osu.edu, Christian Blanco, John Gray, Gopesh Anand

Does a plant's performance in one regulatory domain predict its performance in another? To study this, we merge pharmaceutical/medical device plant-level outcomes related to environmental performance (from the Environmental Protection Agency [EPA]) and quality performance (from the Food and Drug Administration [FDA]). We explore whether, when, and how these two dimensions of performance are related.

■ MD23

CC- Room 3A

Decision Analysis Society Awards

Sponsored: Decision Analysis

Sponsored Session

Chair: Karen Jenni, U.S. Geological Survey, Wheat Ridge, CO, 80033, United States

1 - Student Paper Award

Asa Palley, Indiana University, Bloomington, IN, 47405, United States

The Student Paper Award is given annually to the best decision analysis paper by a student author, as judged by a panel of the Decision Analysis Society of INFORMS. Students who did not complete their PhD. prior to May 1, 2018 are eligible for the 2019 competition. The winner and finalists will be recognized and the winner will give a condensed presentation of their paper.

2 - Publication Award

Canan Ulu, Georgetown University, McDonough School of Business, Operations and Information Management Area, Washington, DC, 20057, United States

3 - Decision Analysis Practice Award

Michael C. Runge, USGS Patuxent Wildlife Research Center, 12100 Beech Forest Rd, Laurel, MD, 20708, United States

The Decision Analysis Practice Award is awarded jointly by DAS and the Society of Decision Professionals to the best example of decision analysis practice as judged by the Decision Analysis Practice Award Committee. The purpose of the award is to publicize and encourage outstanding applications of decision analysis practice. We will present the finalists and this year's winner.

4 - Frank P. Ramsey Medal

Jason R.W. Merrick, Virginia Commonwealth University, Richmond, VA, 23284, United States

The Ramsey Medal of the Decision Analysis Society is awarded for distinguished contributions in decision analysis. Distinguished contributions can be internal, such as theoretical and procedural advances in decision analysis, or external, such as developing or spreading decision analysis in new fields. We will introduce the 2019 Ramsey Medal winner, followed by a presentation by the winner.

■ MD24

CC- Room 3B

Methodological Improvements and Innovative Applications in MCDM

Sponsored: Multiple Criteria Decision Making

Sponsored Session

Chair: Cristiano Cavalcante, Universidade Federal de Pernambuco, Recife Pernambuco, 52070-080, Brazil

Co-Chair: Adiel Teixeira De Almeida, Universidade Federal de Pernambuco, Universidade Federal de Pernambuco, Recife PE, 50630-970, Brazil

1 - A Multicriteria Model to Support Decisions on Investments in Maintenance Quality

Alexandre Alberti, PhD student, UFPE, Recife, Brazil, alexandre.emc091@gmail.com, Cristiano Cavalcante

Maintenance quality can have a significant impact on the performance of a maintenance policy. The investment in higher quality maintenance can be done in different ways, for example by improving the quality of replacements or inspections. Previous works has shown how mathematical models can be used to obtain guidelines for such an investment, considering only the cost criterion. In this work, we present a multicriteria model based on cost and risk criteria, which can be used to obtain such guidelines. The results demonstrate that the multicriteria model can lead to different orientations.

2 - Solving Multicriteria Ranking Problems Based on Partial Information with FITradeoff Method

Eduarda Frej, PhD, UFPE - Universidade Federal de Pernambuco, Recife, Brazil, eafrej@cdsid.org.br, Adiel Teixeira De Almeida

This work aims to presented a methodological tool for solving multicriteria decision making/aiding (MCDM/A) problems in the scope of the ranking problematic using partialinformation about the decision maker's preferences with the FITradeoff method. The process is conducted throughout an interactive decision support system (DSS), and theranking of the alternatives is computed based on pairwise dominance relations, which are obtained throughout linear programming. The DSS presents graphical visualization ofpartial results at any step, in order to facilitate the process for the decision maker.

3 - Maintenance Planning for Electrical System: A Multicriteria Perspective

Cristiano Cavalcante, Universidade Federal de Pernambuco, Rua Antonio de Castro N. 61, Apartment 701, Recife Pernambuco, 52070-080, Brazil, cristianogesm@gmail.com, Augusto Rodrigues, Heldemarcio Ferreira

We propose a multicriteria decision model to support the definition of maintenance planning for electrical system. The model consider important criteria for the performance of substantion. The downtime indirectly measures the degree of undesirability of the duration of interruptions on the energy delivery service; The cost criterion takes into account aspects such as inspection cost, cost of system repair and cost arising from the failure; The probability criterion aims to reduce the chances of a failure occurring through maintenance actions, and also becomes a way to avoid serious consequences. The model allows the decision-maker takes decision with a broader perspective about the problem.

4 - Multi-criteria Decision Model to Support the Maintenance Policy for Circuit Breakears in an Electrical Substation

Rodrigo Sampaio Lopes, assistant Professor, Federal University of Pernambuco, Avenida Cicero Araujo 349, Caruaru-PE, 55021330, Brazil, rodrigoengep@gmail.com, Cristiano Cavalcante

The energy systems are composed of several protection systems that have the function of isolate a fault and protect critical components. In this study we describe the decision problem to establish the frequency of inspection and replacement actions for the circuit breaker. We propose a multi-criteria model considering the preference of the decision maker about the risk and cost criteria and addressing the veto for alternatives. The steps to implement the model are applied to a circuit breaker in a pilot substation in Brazil. The results show the advantages of considering more than one criterion and the preference of the decision maker.

■ MD25

CC- Room 401

Joint Session Not-for Profit/Policy and Gov't/Practice Curated: Operations Research in Public Education

Emerging Topic: Humanitarian and NotforProfit Operations

Emerging Topic Session

Chair: Sebastien Martin, Massachusetts Institute of Technology, Cambridge, MA, 02139, United States

1 - Informal Mentoring and Teacher Turnover

Samantha Meyer Keppler, University of Michigan, Ann Arbor, MI, 48103, United States, Stefanus Jasin, Damian Beil, Minmin Zhang

It is well-established that novice teachers are more likely to stay at their school when they have colleagues who they can turn to for advice as informal or formal mentors. Combining the vast mentoring literature with workforce planning in operations, we show analytically that schools can be in a persistent state of high turnover when they cannot retain teachers long enough to become mentors, as high turnover means fewer mentors which means even higher turnover - a "turnover snowball." We provide managerial and policy insights as to where to focus retention efforts to get schools over the tipping point in teacher retention, so they can maintain enough mentors and reduce turnover further on their own.

2 - A Bounded Formulation for the School Bus Scheduling Problem

Liwei Zeng, Northwestern University, IEMS Department, Evanston, IL, 60208, United States, Karen Smilowitz, Sunil Chopra

This paper proposes a new formulation for the school bus scheduling problem (SBSP) which optimizes starting times for schools and associated bus routes to minimize transportation cost. Specifically, the problem determines the minimum number of buses required to complete all bus routes under the constraint that routes for the same school must arrive within a set time window before that school starts. We present a new integer linear programming (ILP) formulation for this problem which is based on a time-indexed formulation. We develop a randomized rounding algorithm based on the linear relaxation of the ILP that yields near-optimal solutions for large-scale problem instances.

3 - Optimizing Schools' Start Times

Sebastien Martin, Lyft, NYC, NY, 02139, United States, 92sebastien@gmail.com

Spreading start times allows school districts to reduce transportation costs by reusing buses between schools. However, assigning each school a time involves both estimating the impact on transportation costs and reconciling additional competing objectives. These challenges force many school districts to make myopic decisions, leading to an expensive and inequitable status quo. We propose the first algorithm to jointly solve the school bus routing and bell time selection problems. Our application in Boston led to $5 million in yearly savings and to the unanimous approval of the first school start time reform in thirty years.

■ MD26

CC- Room 4C-1

Meet the Service-related Journal Editors

Sponsored: Service Science

Sponsored Session

Chair: Roland T. Rust, University of Maryland, College Park, MD, 20742, United States

1 - Meet the Service-related Journal Editors

Roland T. Rust, University of Maryland, Robert H. Smith School of Business, University of Maryland-College Park, College Park, MD, 20742, United States

This session features editors from four top journals that seek to publish the leading service research. The session features Saif Benjaafar (Editor-in-Chief of Service Science), Mike Brady (Editor-in-Chief of the Journal of Service Research), PK Kannan (Editor-in-Chief of the International Journal of Research in Marketing) and Rob Palmatier (Co-Editor of the Journal of Marketing). Each Editor will discuss what kind of articles his journal seeks, and will describe how best to craft a publishable service research article.

Panelists

- Robert W. Palmatier, PhD, University of Washington, WA, United States
- Saif Benjaafar, University of Minnesota, Department of Industrial and Systems Engr, Minneapolis, MN, 55419, United States
- Pallassana K. Kannan, University of Maryland-College Park, The Robert H. Smith School of Business, Department of Marketing, College Park, MD, 20742-1815, United States
- Michael K. Brady, PhD, Florida State University, FL, United States

■ MD27

CC- Room 4C-2

Data-Driven Resource Planning

Sponsored: Service Science

Sponsored Session

Chair: Haitao Li, Univ of Missouri-St Louis, St Louis, MO, 63121-4400, United States

1 - Scheduling with a Maintenance Activity to Minimize the Maximum Late Work

Yao-Wen Sang, Northwestern Polytechnical University, Xi'an, China, Junqiang Wang

We schedule n independent jobs on a single machine with a flexible maintenance activity. The late work of a job is the amount of processing of the job that is performed after its due date. The objective is to minimize the maximum late work, Vmax. We prove the problem with maintenance activity is NP-hard and propose a pseudo-polynomial dynamic programming algorithm. For the approximability of the problem, we prove that there is no polynomial (1+)-approximation algorithm. After modifying the objective of our problem to Vmax+a, we can design a FPTAS for this modified problem. For the special case without maintenance activity, a polynomial time algorithm is provided.

2 - Data-Driven Optimization for Agile Project Operations

Chidu Subbiah, EdwardJones, Saint Louis, MO, United States, csubbiah@mail.umsl.edu, Haitao Li, Joseph Simonis, Andrea Hupman, Donald C. Sweeney, Joshi Kailash

In Agile IT Project Management practices, there is an important need to make better scheduling and resource allocation decisions to facilitate on-time and on-budget project deliveries. Our work contributes to the research literature and practice in service industry by providing a new data-driven analytical approach built upon predictive analytics for better estimating the project efforts, in conjunction with optimization-based prescriptive analytics using mixed-integer linear programing (MILP). A real-world application of the proposed models at a large services firm is showcased as part of the talk.

3 - Optimizing Large-Scale Stochastic Resource Planning

Haitao Li, Univ of Missouri-St Louis, College of Business Administration, St Louis, MO, 63121-4400, United States, lihait@umsl.edu, Vargas Marcos, Santos Cirpriano

A professional service organization (PSO) often needs to assign a myriad of workforce resources to project jobs, which is known as resource planning (RP). We develop an integrated stochastic resource planning (SRP) model to optimize the here-and-now multi-attribute resource-job assignment decision, while accounting for the expected costs of job loss and resource idleness. We tackle the large-scale SRP by transforming it to a minimum-cost matching problem in an unbalanced bipartite graph. Comprehensive computational experiments show first that our SRP solutions provide significant value over a deterministic certainty-equivalent approach.

4 - Clustering Analysis of Crash Report Data for Identifying and Characterizing Representative Scenarios of Vehicle Crashes

Yu Li, Missouri University of Science and Technology, Rolla, MO, 65401-4587, United States, ylkqm@mst.edu, Md. Al-Amin, Mohammad Karim, Ruwen Qin

Univariate data analysis for identifying causes of vehicle crashes is not sufficient in supporting decision-making. Assisting drivers in recognizing risk scenarios in a real-time manner is in a great need for the safety purpose, which requires a thorough understanding of causes of crash and the concise characterization of risk scenarios. This study retrieved crash report data from FARS and used descriptive analysis to identify risk factors that not only contribute to crashes but can be captured by a vision-based system.

■ MD28

CC- Room 4C-3

Sharing Economy in Service Industry

Sponsored: Service Science

Sponsored Session

Chair: Paolo Roma, University of Palermo, Palermo, Italy

Co-Chair: Paolo Letizia, University of Tennessee, Knoxville, TN, 37996, United States

Co-Chair: Tiziana D'Alfonso, Sapienza University of Rome, Italy

1 - Manufacturing As a Service

Gokce Esenduran, Purdue University, West Lafayette, IN, 47907, United States, gesendur@purdue.edu, Alok R. Chaturvedi, Gaurav Nanda

We study Manufacturing-as-a-Service (MaaS) in a sharing economy context. Motivated by the Project Saksham that was implemented in the state of Jharkhand in India, MaaS brings mobile manufacturing as Factories on Wheels (FOWs) to low-income communities. Called labor firms, these communities have an opportunity to make/sell products and achieve economic growth and stability. To mainstream MaaS in the US, we model the interaction between a social planner, labor firms, and FOWs. Analyzing this problem, we identify how the total welfare progresses, under what conditions the business model would succeed, and what the breakeven point would be from social planner's, labor firms', and FOWs' perspective.

2 - Is Sharing Economy Green?

Paolo Letizia, University of Tennessee, Knoxville, TN, 37996, United States, pletizia@utk.edu, Paolo Roma, Esther Gal-Or, Fahimeh Rahmanniyay

We study the profitability and environmental impact of sharing economy, considering the different incentives of the manufacturer, sharing platform, and consumers. The environmental impact is characterized by the trade-off between the number of products sold and the usage of each product.

3 - The Impact of Sharing Economy on Incumbents' Price and Quality Decisions

Paolo Roma, University of Palermo, Viale delle Scienze, Palermo, Italy, Tiziana D'Alfonso

We study how the sharing economy influences incumbents' price and quality decisions. Specifically, we focus on the hospitality industry and on a duopoly of incumbents. We show that the entry of a sharing economy platforms may have nontrivial effects on both price and quality decisions, and in turn on profitability, of incumbents due to the two contrasting effects of competition and consumers' income increase.

■ MD29

CC- Room 4C-4

Optimization in Matching Markets

Sponsored: Auction and Market Design

Sponsored Session

Chair: Peng Shi, University of Southern California, University of Southern California, Los Angeles, CA, 90064, United States

1 - Optimizing for Distributional Goals in School Choice Problems

Aaron Bodoh-Creed, PhD, University of California, Berkeley, CA, United States

I investigate three goals of school choice: welfare, encouraging neighborhood schools, and diversity. I use optimization problems to find the best stable and incentive compatible match for any combination of these objectives. I apply my framework to data from Boston Public Schools. If the mechanism conditions on demographics, the improvement (relative to the status quo) in student welfare is equivalent to moving 291 students (out of 3,479) to schools one rank higher in their preference lists. Improvements in the distributional goals can be made (e.g., increasing enrollment in neighborhood schools by 50%) without reducing welfare or diversity.

2 - Optimal Priority-Based Matching Mechanisms

Peng Shi, University of Southern California, Los Angeles, CA, 90064, United States, pengshi@usc.edu

I develop a tractable methodology for designing an optimal priority system for assigning agents to heterogeneous items while accounting for choice behavior. The space of mechanisms being optimized includes deferred acceptance and top trading cycles as special cases. The methodology is based on analyzing large market models of one-sided matching using techniques of network revenue management, and solving a certain assortment planning problem whose objective is social welfare. I apply the methodology to school choice and show that restricting choice may be beneficial to student welfare. Moreover, I compute optimized choice sets and priorities for elementary school choice in Boston.

3 - The Cutoff Structure of Top Trading Cycles in School Choice

Irene Lo, Stanford University, Stanford, CA, 94306, United States, ilo@stanford.edu, Jacob Leshno

We develop a tractable theoretical framework for the Top Trading Cycles (TTC) mechanism for school choice that can be used to quantify welfare and optimize policy decisions. Our framework relies on a novel characterization of the TTC assignment in terms of a cutoff for each pair of schools. We use our framework to compute welfare for TTC and Deferred Acceptance (DA) under different priority structures, and find that the choice of priorities can have larger welfare implications than the choice of mechanism. We solve for the welfare-maximizing distributions of school quality for parametrized economies, and find that optimal investment decisions can be very different under TTC and DA.

4 - Matching Algorithms for Blood Donation

John P. Dickerson, Assistant Professor, University of Maryland, College Park, MD, 20742, United States, john@cs.umd.edu, Duncan McElfresh, Christian Kroer, Sergey Pupyrev, Eric Sodomka

Managing perishable inventory, such as blood stock awaiting use by patients in need, has been a topic of research for decades. We develop policies for matching potential blood donors to donation centers under various constraints and donor preferences, and under simple models of demand shocks to the system. We provide preliminary experimental results in simulation using real data from a large, worldwide social network, and show that our system provides lift relative to the status quo allocation methods.

5 - Spatio-Temporal Pricing for Ridesharing Platforms

Hongyao Ma, Harvard University, MD 242, Cambridge, MA, 02138, United States, Fei Fang, David C. Parkes

A challenge in dynamic pricing in ridesharing platforms is to set prices that are appropriately smooth in space and time, so that drivers will choose to accept their dispatched trips, rather than drive to another area or wait for a better trip. We introduce the Spatio-Temporal Pricing (STP) mechanism, which is subgame-perfect incentive compatible for drivers, and also welfare-optimal, envy-free, individually rational and budget balanced from any history onward. We prove that there can be no dominant-strategy mechanism with the same economic properties, and show via simulation that STP achieves significantly higher social welfare than a myopic pricing mechanism, where drivers have high regret.

■ MD29a

CC- Room 400

Health Care, Modeling and Optimization VIII

Contributed Session

Chair: Jian Hu, University of Michigan-Dearborn, Dept. of IMSE,, Dearborn, MI, 48128, United States

1 - Identifying Influential Individuals and Predicting Future Demand of Chronically Ill Patients

Zlatana Nenova, University of Denver, Denver, CO, United States, zlatana.nenova@du.edu, Valerie Bartelt

We develop a generalizable framework which (1) identifies high impact and stable-demand customers and (2) predicts the medium-term demand for services of stable-demand customers. Identifying high impact individuals can be used in (1) monitoring prioritization, (2) patients' motivation and (3) patients' stabilization. Predicting need for care of stable demand individuals up to three years into the future is critical for hospital management in identifying future hiring needs. We evaluate our method by leveraging a large electronic medical records' data set, which comprises of 48,344 chronic kidney disease patients treated across eleven geographically diverse VA hospitals.

2 - Optimization of Admission Policies with Dynamic Capacity in Inpatient Ward Units

Jorge Acuna, PhD Student, University of South Florida, Tampa, FL, United States, jorge@mail.usf.edu, Jose L. Zayas-Castro

Admission of patients plays a fundamental role in hospital overcrowding management as well as patient outcomes and quality of care. In this talk, we formulate and solve a Markov Decision Process (MDP) to optimize the admission of different classes of patients to hospital inpatient ward with dynamic capacity. We discuss how better admissions policies that consider the different patient length of stay (LOS) can help to improve access to care. At the same time, we provided two different methods to overcome the curse of dimensionality of the MDP model with embedded prediction techniques of LOS and demand. We conclude with insights for the model implementation and the primal and dual acceptance policies.

3 - Planning Response to Medical Needs During Mass Gatherings

Mohammadreza Torkjazi, West Virginia University, Morgantown, WV, 26505, United States, mt0055@mix.wvu.edu, Behrooz Kamali, Leily Farrokhvar

Medical response during mass gatherings (MG) requires detailed prior planning due to the presence of a large number of crowds in a relatively small area in a short window of time. Medical care is either provided on-site (e.g., temporary care facilities), off-site (e.g., nearby hospitals) or using a combination of both during MG events. We propose mathematical models to study the trade-offs between different care policies and identify optimal and near-optimal service strategies. We use simulation to compare and analyze the results from our models.

4 - Mean-Risk Two Stage Vaccine Allocation to Geographically Different Regions under Uncertainty

Amira Mahmoud Hijazi, NC State University, Raleigh, NC, United States, amhijazi@ncsu.edu, Osman Ozaltin, Maria Jansen

CDC estimated that 25 million people became infected in the U.S. during the 2015-2016 flu season. While most of these cases were mild, there were approximately 12,000 flu-related deaths and 310,000 related hospitalizations. The economic burden of influenza on the U.S. economy is estimated to be $10.4 billion annually in direct medical costs, and $16.3 billion in indirect costs such as lost earnings. Vaccination is the most effective way of preventing influenza. In this study, we consider a risk-averse two-stage stochastic vaccine allocation model, where we specify the conditional-value-at-risk (CVaR) as the risk measure. We apply The sample average approximation (SAA) method to distribute flu vaccines to North Carolina State counties over two time phases.

5 - Dynamic Surveillance and Contact-tracing Policies for Outbreaks

Soheil Eshghi, Postdoctoral Associate, Yale University, New Haven, CT, United States, soheil.eshghi@yale.edu, Wasiur R. KhudaBukhsh, Eben Kenah, Grzegorz A. Rempala, Forrest W. Crawford

Enhanced surveillance (ES) and contact-tracing (CT) are policies that find and treat infected individuals in outbreaks. ES augments baseline surveillance through random testing. Once an index case is found, CT finds and treats their infected contacts. Each policy has fixed and variable costs. Under a simple epidemic model, the optimal dynamic coordinated policy that balances a trade-off between disease burden and policy expenditure uses each of these policies at either their highest intensity or not at all, traces at a subset of the times it surveils, and only switches each on and off once. This structure suggests simple heuristic policies for real-world outbreaks.

6 - A Two-stage Resilient Dynamic Programming Model for Nurse Scheduling Problem under Uncertainty

Jian Hu, University of Michigan - Dearborn, Dearborn, MI, United States, jianhu@umich.edu

This study is to find the optimal resilient policies of nurse scheduling for both improving serve quality of hospitals and respecting nurses job satisfaction under workload uncertainty. Major challenges in nurse scheduling problems are three key factors of workload uncertainty: unforeseen patient demand, nurse absenteeism, as well as nurse willingness to volunteer to work additional hours. The research proposes a stochastic dynamic optimization model, where the here-and-now decision in the planning stage makes an initial schedule, and the wait-and-see decisions in the operation stage finds the optimal daily on-call policy to adjust the schedule for the realization of nurse workload.

■ MD30

CC- Room 6A

Tutorial: Wasserstein Distributionally Robust Optimization: Theory and Applications in Machine Learning

Emerging Topic: Tutorials

1 - Wasserstein Distributionally Robust Optimization: Theory and Applications in Machine Learning

Daniel Kuhn, Ecole Polytechnique Federale de Lausanne (EPFL), Lausanne, 1015, Switzerland, Peyman Mohajerin Esfahani, Viet Anh Nguyen, Soroosh Shafieezadeh-Abadeh

Many decision problems in science, engineering and economics are affected by uncertain parameters whose distribution is only indirectly observable through samples. The goal of data-driven decision-making is to learn a decision from finitely many training samples that will perform well on unseen test samples. This learning task is difficult even if all training and test samples are drawn from the same distribution — especially if the dimension of the uncertainty is large relative to the training sample size. Wasserstein distributionally robust optimization seeks data-driven decisions that perform well under the most adverse distribution within a certain Wasserstein distance from a nominal distribution constructed from the training samples. In this tutorial we will argue that this approach has many conceptual and computational benefits. Most prominently, the optimal decisions can often be computed by solving tractable convex optimization problems, and they enjoy rigorous out-of-sample and asymptotic consistency guarantees. We will also show that Wasserstein distributionally robust optimization has interesting ramifications for statistical learning and motivates new approaches for fundamental learning tasks such as classification, regression, maximum likelihood estimation or minimum mean square error estimation, among others.

■ MD31

CC- Room 6B

Military and Security (MAS) Society Awards

Sponsored: Military and Security

Sponsored Session

Chair: Andrew Hall, United States Army Cyber Research Institute, United States Army Cyber Research Institute

1 - Seth Bonder Scholarship

Nicholas Shallcross, DoD/University of Arkansas, Fayetteville, AR, 72701, United States

The recipient gives a presentation on the research thread for which this scholarship is bestowed. The award-winning research thread is titled, “Demonstrating Set-based Design Concepts in Support of U.S. Army Ground Combat Vehicle Acquisition Decisions.

2 - Koopman Prize

Miguel Lejeune, George Washington University, Washington, DC, 20052, United States

The recipients present their award-winning work from 2018, which was published in Management Science. The presented research focuses on “Aeromedical Battlefield Evacuation Under Endogenous Uncertainty in Casualty Delivery Times”.

3 - J. Steinhardt Prize

Jeffrey Kline, Naval Postgraduate School, Salinas, CA, 93908, United States

The recipient will share insights, observations, and professional wisdom from a highly-regarded, impactful career of contributions. Dr. Kline’s career has supported both the education of graduate military officer students and the informing of senior policy makers in the Navy and Department of Defense, all to plan and analyze military plans and operations.

4 - MAS Award Opportunities

Andrew Oscar Hall, United States Military Academy, West Point, NY, 10996, United States

The past president and awards chair for the Military and Security (MAS) Society will provide an overview of award opportunities within the society, host a discussion about how to apply for these opportunities, and share information about developing awards within MAS.

■ MD32

CC- Room 6C

Operations Management II

Contributed Session

Chair: Henny van Ooijen, Eindhoven University of Technology, Eindhoven, 5600MB, Netherlands

1 - Swan or Ugly Duckling? An Investigation of Zero-waste Management

Mikeum Kim, Korea University, Seoul, Korea, Republic of, mkkim01@korea.ac.kr, Byung Cho Kim

This paper examines the viability of zero-waste model. We identify the conditions under which the firm’s zero-waste action brings profit in the presence of two types of consumers, including primary consumers and eco-conscious consumers. Our preliminary results show that the size of the eco-conscious consumer segment and the level of consumers’ perception influence on the viability of zero-waste model. We aim to make contributions to the operations management literature by incorporating consumer behavior into manufacturer’s decision-making.

2 - Effect of Balance of Quality Features on Business Performance

Hyunjung Kim, Prof., Sunchon National University, Suncheon-si, Korea, Republic of, hkim@scnu.ac.kr

The relationship between quality and business performance has attracted theoretical attention. The purpose of this study was to investigate the missing point between quality and business performance which might connect them more strongly. This study suggests decision stage which is positioned between perceived quality features and actual purchase. According to the different standard of decision, different choices can be made under the same perceived quality level. As a result, balanced features of quality performed better than unbalanced features of quality even though the former has lower average quality level.

3 - Age Replacement Policy under Presence of Cyber Threats

Anh Ta, University of North Texas, Denton, TX, United States, Hakan Tarakci

This study provides analytical models to deal with cyber-threats in a production system that utilizes the age replacement policy. Two different scenarios involving cyber-threats are proposed. First, cyber-attacks do not disrupt the physical production system. The broken components are replaced either when the system has a physical breakdown or when a predetermined amount of time elapses. Second, the system is replaced right after it suffers from a successful cyber-attack. We analytically provide optimal policies to minimize the expected cost for these scenarios. Finally, sensitivity analyses show the effect of model parameters on the value of a cyber security system.

4 - Valuing Decision Lead Time under Non-constant Residual Value

Lauri Saarinen, Assistant Professor, Aalto University, Espoo, Finland, lauri.3.saarinen@aalto.fi, Suzanne de Treville

The amount that a decision maker should be willing to spend to reduce the decision lead time depends on the residual value under the assumption that the residual value is constant. We develop a theoretical model to explore how the value of responsiveness changes when the residual value is stochastic: Not considering stochasticity will cause the decision maker to undervalue responsiveness. Data from a consumer goods company exemplifies different forms that the relationship between expected leftover inventory and residual value might take.

5 - Performance Analysis of Flow Lines with Planned Work Center Order Release Times: A Queueing Approach

Henny van Ooijen, Eindhoven University of Technology, Eindhoven, Netherlands, h.p.g.v.ooijen@tue.nl

Literature on setting planned lead times for flow lines often assumes that the throughput time distributions of the different work centers are known, for instance based on practical data. In this study we develop a queueing based approach to determine the throughput time distributions for flow lines with planned release dates.

■ MD33

CC- Room 602

Latest Developments in Optimization Software

Sponsored: Optimization/Computational Optimization and Software

Sponsored Session

Chair: Hans Mittelmann, Arizona State University, Tempe, AZ, 85287-1804, United States

1 - Latest Benchmark Results

Hans Mittelmann, Arizona State University, Mathematics and Statistics, PO Box 871804, Tempe, AZ, 85287-1804, United States, mittelmann@asu.edu

The latest results from our benchmarks of non-commercial and some commercial software for continuous and discrete optimization will be presented.

2 - Recent Improvements in the Gurobi Optimizer

Edward Rothberg, Gurobi Optimization, LLC, Beaverton, OR, 77027, United States, rothberg@gurobi.com

This talk will present the latest features and improvements in the new version of the Gurobi Optimizer.

3 - Latest Developments in the Artelys Knitro Optimization Solver

Richard Waltz, Artelys Corp, Los Angeles, CA, United States

Artelys Knitro is the premier solver for nonlinear optimization problems. Knitro offers both interior-point and active-set algorithms for continuous models, as well as tools for handling problems with integer variables and other discrete structure. This talk will highlight the latest developments and improvements in Knitro, i ncluding a new algorithm designed for second order cone constraints, and advances in mixed-integer nonlinear optimization.

4 - What's New in CPLEX

Roland Wunderling, IBM, Austria, roland.wunderling@at.ibm.com

We will present the performance improvements realized in the latest release of CPLEX and describe the ideas that helped achieve them.

■ MD34

CC- Room 603

Stochastic Optimization in Machine Learning

Sponsored: Optimization/Global Optimization

Sponsored Session

Chair: Zhengyuan Zhou, Stanford, CA, 94305, United States

1 - Algorithm Design Through the Lens of Optimal Transport

Zhaoran Wang, Assistant Professor, Northwestern University, Evanston, IL, United States, zhaoran.wang@northwestern.edu

Infinite-dimensional distributional optimization is prevalent in machine learning. Typical examples include Bayesian estimation, generative adversarial learning, distributionally robust optimization, and online & reinforcement learning. In fact, any (possibly nonconvex) optimization problem can be lifted into a linear infinite-dimensional optimization problem. In this talk, I will present a unified approach of dimensional optimization through the lens of optimal transport. (Joint work with Yongxin Chen and Zhuoran Yang)

2 - Randomized Alternating Directions Methods for Distributed Optimization

Mert Pilanci, Professor, Stanford University, Stanford, CA, United States, pilanci@stanford.edu

We consider large scale distributed machine learning problems where the data rows are split across different machines. We propose a novel randomized variant of the Alternating Direction Method of Multipliers (ADMM), where random projections are applied instead of sampling the data. On least squares problem, we prove that the randomized ADMM converges in constant number of steps, independent of the condition number, and how the data rows are split. Moreover, our method is always guaranteed to converge with no tuning parameters. In contrast, classical ADMM requires tuning parameters and can take an arbitrarily large number of steps depending on the local conditioning of the partitioned data.

3 - On the Parallel Complexity of Non-smooth Optimization

Aaron Sidford, Professor, Stanford University, Stanford, CA, United States, sidford@stanford.edu

In this talk I will discuss recent advances in designing parallel algorithms for minimizing non-smooth convex functions. In particular, I will present new upper and lower bounds on the parallel complexity of non-smooth convex function minimization. This talk will emphasize new stochastic accelerated methods for this problem and additional applications for solving large scale learning problems. This talk reflects joint work with Sebastien Bubeck, Qijia Jiang, Yin Tat Lee, and Yuanzhi Li.

4 - Understanding the Importance of Noise in Training Neural Networks

Tianyi Liu, Georgia Institute of Technology, School of Industrial and Systems Engineering, Atlanta, GA, 30332, United States, Mo Zhou, Yan Li, Dachao Lin, Enlu Zhou, Tuo Zhao

Empirical evidences have corroborated that the noise plays a crucial rule in effective and efficient training of neural networks. The theory behind, however, is still largely unknown. Our work studies this fundamental problem through training a simple two-layer convolutional neural network model. Although training such a network requires solving a nonconvex optimization problem with a spurious local optimum and a global optimum, we prove that perturbed gradient descent in conjunction with noise annealing is guaranteed to converge to a global optimum in polynomial time. This implies that the noise enables the algorithm to efficiently escape from the spurious local optimum.

5 - When Nonconvexity Meets Non-smoothness

Ju Sun, Stanford University, Stanford, CA, United States, sunju@stanford.edu

Most applied problems we encounter can be naturally written as nonconvex optimization, which in theory is hard to solve globally. In practice, however, simple methods often work surprisingly well in finding high-quality solutions. In this talk, I will describe recent efforts in bridging the mysterious theory-practice gap. I will highlight a family of smooth nonconvex problems that can be solved to global optimality using simple methods. The discovery does not cover nonsmooth functions, which are increasingly popular in modern applications. I will introduce tools from nonsmooth analysis, and show how nonsmooth, nonconvex problems can also be analyzed and solved in a provable manner.

■ MD35

CC- Room 604

Packing and Covering

Sponsored: Optimization/Integer and Discrete Optimization

Sponsored Session

Chair: Yuri Faenza, Columbia University, New York, NY, 10027, United States

1 - Mixed-integer Programming Techniques for Strategic Open-pit Mine Planning

Gonzalo Muñoz, Polytechnique Montreal, Montreal, QC, H3T 1N8, Canada, Orlando Rivera, Daniel G. Espinoza, Marcos Goycoolea, Eduardo Moreno

Computing production schedules for strategic open pit mine planning has proved to be an elusive problem. Using a block representation of the ore body, a schedule must specify which blocks should be extracted, when, and how will they be processed so as to maximize the value of a project. Given the size of real-world mines and the presence of knapsack and spatial constraints, among others, instances can have hundreds of millions of variables, and many times more constraints. In this talk, we describe a MIP methodology for finding an optimal schedule which combines preprocessing, cutting-planes, heuristics, and a branch-and-bound algorithm. We show extensive computational tests using real problem sets.

2 - Approximating Integer Programs with Monomial Orders

Akshay Gupte, Clemson University, Dept. of Mathematical Sciences, Clemson, SC, 29634-0975, United States, agupte@clemson.edu

We present an approach for creating primal and dual bounds for a general integer program using monomial orders on the integer lattice. We give approximation guarantees for these bounds with respect to the integer optimum. In particular, we show that for certain monomial orders, the dual bounds converge to the integer optimum of packing and covering 0/1 IPs, and the primal bounds converge for any 0/1 IP. The complexity of computing our bounds is also discussed. Some preliminary computational results for MIPLIB instances will also be presented.

3 - The Generalized Incremental Knapsack Problem

Lingyi Zhang, Columbia University, New York, NY, United States, lz2573@columbia.edu, Yuri Faenza

The Generalized Incremental Knapsack (GIK) problem is an extension of the classical Knapsack problem to a discrete, multi-period setting, naturally modelling scenarios where the available resources increase over time. GIK is strongly NP-Hard, hence strictly harder than the classical Knapsack. Special cases of this problem (IK, IIK) have recently been studied in literature. In this talk, we present new polyhedral and algorithmic results for GIK.

5 - Covering Problems: Pitch and Extended Formulations

Xuan Zhang, Columbia University, New York, NY, 10025, United States, Daniel Bienstock, Yuri Faenza

Consider covering problem Ax>=b with x binary. The pitch of a valid inequality cTx>=d is the minimum integer p such that the p smallest non-zero coefficients in c sum up to at least d. Pitch is therefore a way to measure complexity of inequalities. Pitch is connected to other relevant concepts in integer programming such as the Chvátal-Gomory closure. In this talk, we investigate bounded pitch inequalities for the minimum knapsack (aTx>=b) and the set covering (Ax>=1) problems. In particular, we investigate their relationship with inequalities of bounded coefficients and give bounds on the size of extended formulations for relaxations of covering problems when inequalities of bounded pitch are added.

■ MD36

CC- Room 605

Emerging Topics in Data-Driven Optimization

Sponsored: Optimization/Optimization Under Uncertainty

Sponsored Session

Chair: Vishal Gupta, University of Southern California, Los Angeles, CA, 90026, United States

Co-Chair: Michael Huang, University of Southern California, Los Angeles, CA, United States

1 - Data-Pooling for Stochastic Optimization

Vishal Gupta, University of Southern California, Marshall School of Business, Los Angeles, CA, 90026, United States, guptavis@usc.edu, Nathan Kallus

When simultaneously solving many unrelated, data-driven stochastic optimization problems, optimization intuition suggests decoupling and solving them separately. We propose a novel data-pooling algorithm that combines data across unrelated problems and generally outperforms decoupling. We study causes of this phenomenon, when it holds, and prove our method learns the optimal amount of pooling in the small-data, large-scale regime. We propose refinements that leverage covariates and illustrate through real-world applications in inventory and vehicle routing.

2 - Interpretable Optimal Stopping

Velibor Misic, UCLA Anderson School of Management, Los Angeles, CA, 90095, United States, velibor.misic@anderson.ucla.edu, Florin Ciocan

Optimal stopping is the problem of deciding when to stop a stochastic system to obtain the greatest reward. State of the art methods for this problem rely on obtaining an approximate value function for use within a greedy policy. However, such policies are generally not interpretable, in that it is often difficult to see how the policy maps each system state to a decision. We propose a new data-driven method for optimal stopping that directly learns interpretable policies in the form of binary trees. We apply our approach to a canonical option pricing problem and show that it quickly obtains interpretable policies that outperform existing non-interpretable policies based on simulation-regression.

3 - Small-data, Large-scale Discrete Optimization

Michael Huang, University of Southern California, Los Angeles, CA, 90007, United States, huan076@usc.edu, Vishal Gupta, Paat Rusmevichientong

We propose a method for data-driven, discrete optimization problems in the small-data, large-scale regime, i.e., problems that depend on many uncertain parameters, each with highly imprecise estimates. The key idea is to use a novel decomposition approach to optimize out-of-sample performance. We prove our method achieves best-in-class performance for a variety of problems such as shortest path, minimum spanning tree, and weighted maximum independent set.

4 - Bounding Optimality Gaps via Bagging

Huajie Qian, Columbia University, New York, NY, 10027, United States, Henry Lam

We investigate a statistical method to assess the suboptimality of a given solution in data-driven stochastic optimization, via estimating the solution's optimality gap. Our approach is based on bootstrap aggregating, or bagging, resampled sample average approximation (SAA). We show how this approach generates valid statistical confidence bounds for non-smooth optimization, and demonstrate and compare its statistical efficiency and stability with some existing methods. We also present our theory by viewing SAA as a kernel in an infinite-order symmetric statistic, which leads to some generalizations of classical central limit results for SAA.

■ MD37

CC- Room 606

Applications of robust optimization

Sponsored: Optimization/Optimization Under Uncertainty

Sponsored Session

Chair: Aurelie Thiele, Southern Methodist University, Dallas, TX, 75275-0123, United States

1 - Robust Continuous Optimisation for Project Portfolio Management under Uncertainty

Hedieh Ashrafi, Southern Methodist University, Dallas, TX, 75206, United States, Aurelie Thiele

We consider the management of projects under uncertainty in a firm's market entry, competitors' entry and product adoption dynamics. The company can adjust manpower staffing on a portfolio of projects (new products), which diversifies its portfolio but delays market entry for each product line, making it more likely a rival will launch a competing product first. We present a robust optimisation approach to balance those concerns and extend our framework to dynamic policies based on information revealed over time about competitors' products entering the market. We provide insights into when it is optimal for the manager to focus on a narrow range of new products.

2 - Determining Facility Locations under Distributionally Robust Decision-dependency

Beste Basciftci, Georgia Institute of Technology, H. Milton Stewart School, Atlanta, GA, 30332, United States, beste.basciftci@gatech.edu, Siqian Shen, Shabbir Ahmed

We study distributionally robust facility location problem under decision-dependent demand distribution, motivated by an example from a car sharing setting. We propose a moment-based ambiguity set that captures the underlying uncertainty based on the location decisions. Furthermore, we develop a mixed-integer linear programming reformulation under the proposed ambiguity set and strengthen the formulation by deriving valid inequalities. Our case study illustrates superior performance of the proposed approach in comparison to distributionally robust and stochastic programming methods which omit decision-dependency.

3 - Inverse Markov Decision Processes with Unknown Transition Probabilities

Zahra Ghatrani, University of Washington, Kirkland, WA, United States, Archis Ghate

Inverse optimization is a framework for inferring parameters of an optimization problem (cost coefficients, right-hand side vector, or the constraint matrix) given observed values of decisions. We study the problem of Inverse Markov Decision Processes (MDP) with unknown transition probabilities. We consider the inverse MDP problem under different assumptions about the observed solution. We show that in special cases we can use a variable transformation method which reduces solving the inverse MDP problem to a linear program (LP). Then, we extend our work to more general LPs and Semi-Definite programs.

4 - Understanding Distributional Ambiguity via Non-robust Chance Constraint

Shumin Ma, City University of Hong Kong, Kowloon Tong, Hong Kong, shuminma@cityu.edu.hk, William Cheuk Hang Leung, Qi Wu

The DRO formulation resolves distribution uncertainty in portfolio optimization but it's difficult to determine and interpret the ambiguity radius. We show that DRO problem is asymptotically equivalent to mean-deviation problem with investor's risk aversion controlled by radius. Theoretical and numerical analysis show there exists a radius threshold, crossing which optimal value/solution exhibit phase transition, and beyond which, distribution uncertainty takes effect. We also show, a DRO problem with bound constraint can be cast as a deterministic chance constrained optimization (CCO). Without boundedness, the CCO problem uniformly outperforms the DRO problem.

5 - Multi-stage Robust Optimization with Time-dependent Uncertainty Sets

Arkajyoti Roy, The University of Texas at San Antonio, San Antonio, TX, United States, arkajyoti.roy@utsa.edu, Shaunak Dabadghao, Victor Wu

Uncertainties that vary in time can limit the success of conventional robust optimization models, which assume invariant uncertainty sets. We develop a multi-stage robust optimization model that incorporates time-dependent uncertainty sets and provide tractable reformulations. Furthermore, we derive optimal schedules for the multi-stage robust model. An application in cancer radiotherapy is used to demonstrate the performance of the proposed methodology.

■ MD38

CC- Room 607

Theory and Applications in Distributionally Robust Optimization

Sponsored: Optimization/Optimization Under Uncertainty

Sponsored Session

Chair: Zhenzhen Yan, Nanyang Technological University, Singapore, 637371, Singapore

1 - Data-driven Robust Optimization with Known Marginal Distributions

Rui Gao, University of Texas at Austin, Austin, TX, 78712, United States, rgao32@gmail.com

A key challenge in decision making under uncertainty is seeking robust solutions against high-dimensional data uncertainty. The joint distribution of the stochastic data can hardly ever be obtained exactly, even when estimation on their one-dimensional marginals is rather accurate. We propose a distributionally robust approach, which hedges against a family of joint distributions with known marginals and a dependence structure similar to that of a nominal joint distribution (e.g., the empirical or the independent product distribution). We obtain a tractable reformulation of this problem and demonstrated with portfolio selection and nonparametric density estimation.

2 - Robust Vehicle Allocation with Uncertain Covariates

Zhenyu Hu, National University of Singapore, Singapore, 119245, Singapore, bizhuz@nus.edu.sg, Zhaowei Hao, Long He, Jun Jiang

Motivated by a major taxi operator in Singapore, we consider the idle vehicle allocation problem, where the operator reallocates the idle vehicles to serve future uncertain demands. The main challenge lies in estimating demand distribution accurately from historical data. We employ a distributionally robust optimization approach that utilizes covariate information as well as the moment information of demands. We show that covariate information could alleviate the over-conservativeness of the robust solution. The resulting optimization problem can be tractably solved. We further validate our solution via a case study using trip and vehicle status data paired with rainfall data.

3 - Distributionally Robust Optimization with Confidence Bands for Probability Density Functions

Guanglin Xu, University of North Carolina at Charlotte, Charlotte, NC, 52242, United States

We study a stochastic program where the distribution is not completely known and only a set of historical data or some information of the shape of the distribution is available. We apply a data-driven approach to construct an ambiguity set consisting of all the probability density functions that could have generated the available data. The resultant distributionally robust optimization is computationally intractable due to the fact that it has both infinitely many constraints and infinitely many decision variables. We reformulate the problem into a semi-infinite program and propose an effective stochastic gradient method to solve it. The numerical results illustrate the strength of our approach.

4 - Allocation Inequality in Cost Sharing Problem

Zhi Chen, Assistant Professor, City University of Hong Kong, Imperial College Business School, Sout, Hong Kong, SW7 2AZ, China, Zhenyu Hu, Qinshen Tang

We consider the cost sharing problem where a coalition of agents, each endowed with an input, shares the output cost incurred from the total coalitional input. We bridge two important allocations—-average cost pricing and the Shapley value—-from the angle of allocation inequality. We use the concept of majorization to characterize allocation inequality and we derive simple conditions under which one allocation majorizes the other.

■ MD39

CC- Room 608

RAS Interactive Session

Sponsored: Railway Applications

Sponsored Session

Chair: Clark Cheng, Norfolk Southern Corporation, Norfolk, VA, 23510, United States

1 - RAS Interactive Session

Clark Cheng, Sr. Dir Ops Research - Chief Data Scientist, NS Corp, Norfolk, VA, United States

In the RAS Interactive Session, railroads, academics, consultants and suppliers will showcase their latest models and cutting-edge technologies in optimization, simulation and advanced analytics. This year's interactive session includes presentations from AMTRAK, BNSF, CSX, Norfolk Southern, and GE Transportation/Wabtec. The topics range from train scheduling, intermodal hub and port optimization, service design and car routing tools, and predictive maintenance. Attendees will have the opportunity to ask questions and exchange ideas with the presenters in an informal and interactive setting.

■ MD40

CC- Room 609

Recent Advances in Large-Scale optimization

Sponsored: Optimization/Nonlinear Programming

Sponsored Session

Chair: Hoi-To Wai

Co-Chair: Cesar A Uribe, MIT, Cambridge, MA, 02138, United States

1 - Stochastic Decentralized Nonconvex Optimization for Training Over Networks

Songtao Lu, AI Resident, IBM Research, Yorktown Heights, NY, 55414, United States, lus@umn.edu, Mingyi Hong

In this work, we propose a gradient-tracking based nonconvex stochastic decentralized (GNSD) algorithm for solving nonconvex optimization problems, where the data is partitioned into multiple parts and processed by the local computational resource. Through exchanging the parameters at each node over a network, GNSD is able to find the first-order stationary points (FOSP) efficiently. From the theoretical analysis, it is guaranteed that the convergence rate of GNSD to FOSPs matches the well-known convergence rate $\mathcal{O}(1/\sqrt{T})$ of stochastic gradient descent by shrinking the step-size.

2 - A Doubly Stochastic Surrogate Optimization Scheme for Non-convex Finite-sum Problems

Eric Moulines, Professour, Ecole Polytechnique, Dept TSI, France, eric.moulines@polytechnique.edu

Many constrained, nonconvex optimization problems can be tackled using the Majorization-Minimization (MM) method. For problems which minimize a finite sum of functions, a stochastic version of the MM method selects a batch of functions at random at each iteration and optimizes the accumulated surrogate. In many cases of interest, the surrogate functions are expressed as an expectation. We propose a doubly stochastic MM method based on Monte Carlo approximation of these stochastic surrogates. We establish non-asymptotic convergence of our scheme in a constrained nonconvex optimization setting. Several numerical examples are presented to illustrate the performance of the proposed scheme.

3 - Incremental Optimization with Smooth Inference for Structured Prediction

Zaid Harchaoui, University of Washington, Seattle, WA, United States

We present a framework to train a structured prediction model byperforming smoothing on the inference algorithm it builds upon.Smoothing overcomes the non-smoothness inherent to the maximum marginstructured prediction objective, and paves the way for the use of fastprimal gradient-based optimization algorithms. We illustrate theproposed framework by developing a novel primal incrementaloptimization algorithm for the structural support vector machine. Theproposed algorithm called Casimir blends an extrapolation scheme foracceleration and an adaptive smoothing scheme and builds upon thestochastic variance-reduced gradient algorithm. We establish itsworst-case global complexity bound and present numerical results innatural language process and computer vision applications.

4 - Bayesian Decision Making in Groups is Hard

M. Amin Rahimian, MIT, Cambridge, MA, United States, Elchanan Mossel, Jan Hazla, Ali Jadbabaie

We study the computations that Bayesian agents undertake when exchanging opinions over a network. The agents act repeatedly on their private information and take myopic actions that maximize their expected utility according to a fully rational posterior belief. We show that such computations are NP-hard for two natural utility functions: one with binary actions, and another where agents reveal their posterior beliefs. In fact, we show that distinguishing between posteriors that are concentrated on different states of the world is NP-hard. Therefore, even approximating the Bayesian posterior beliefs is hard. We also describe a natural search algorithm to compute agents' actions, which we call the elimination of impossible signals, and show that if the network is transitive, then the algorithm can be modified to run in polynomial time.

■ MD41

CC- Room 610

Conic Optimization in Machine Learning

Contributed Session

Chair: Fabion Kauker, 3-GIS, Decatur, AL, 35601, United States

1 - Linear Programming Based Approach for Signal Separation

Mujahid N. Syed, KFUPM, Dhahran, Saudi Arabia, snumujahid@gmail.com

In this work, a novel optimization algorithm is proposed to solve a specific case of the blind signal separation problem.

2 - A Preordering Algorithm to Reduce Bit-lengths When Exactly Solving Sparse Linear Systems via Integer Preserving LU and Cholesky Factorizations

Christopher Lourenco, Texas A&M University, College Station, TX, United States, clouren@tamu.edu, Erick Moreno-Centeno

When exactly solving sparse linear systems via integer-preserving LU and Cholesky factorizations, a tradeoff exists between fill-in and bit-length (i.e., cost of operations) in the L and U factors. We propose a new algorithm, based on the widely used minimum degree heuristic, which adds node weights to the graph of the input matrix and generates an elimination ordering which both reduces fill-in and bit-length in the ensuing factorization. Associated computational results illustrate that the new algorithm dramatically reduces the worst case run time of the exact factorizations.

3 - A Novel Feature Selection Algorithm for Continuous Response Prediction with Interacting Variables

Maryam Nikouei Mehr, Iowa State University, Ames, IA, United States, Sigurdur Olafsson

This paper concerns a new feature selection method for multiple linear regression models. While common feature selection methods focus on the removal of redundant or irrelevant features, we show that such features may be important. We establish a computational framework for selecting a subset of features that have significant interactions with the response and a subset of features that may have little interactions with the response, but when combined with others, they can be strongly predictive of the response. Removal of these features can thus result in poor predictions. A mixed integer linear programming model is implemented to recognize feature interactions and their exact combinations.

4 - Porting an Open Source LP Solver to Web Assembly

Fabion Kauker, 3-GIS, Decatur, AL, United States, fkauker@3-gis.com

As new applications of optimization require different access methods to solvers new technologies must be explored. The evolution in browser technology has lead to WebAssembly (WASM) this enables code written for what was once server/local application code to be compiled and then run in the browser on the client side. By taking a solver written in C/C++ and porting the interface to be usable in the browser we examine the utility of the interface and example formulations.

■ MD42

CC- Room 611

Computational Challenges and Applications of Network Optimization

Sponsored: Optimization/Network Optimization

Sponsored Session

Chair: Minjiao Zhang, Kennesaw State University, Kennesaw, GA, 30144, United States

1 - Strict Quotas or Tariffs? Implications for Product Quality and Consumer Welfare in Differentiated Product Supply Chains

Dong Li, Babson College, MA, 02481, United States, dli@babson.edu, Anna B. Nagurney, Deniz Besik

We introduce a supply chain network equilibrium model with differentiated products where firms compete on product quantities and quality. We then extend the model to include trade policy instruments in the form of a strict quota or a tariff. We also establish the equivalence between the model with a strict quota and that with a tariff, when the quota constraint is tight. Illustrative examples as well as a case study on soybeans, an important global agricultural product, reveal interesting insights with accompanying suggestions for policy-makers. Specifically, although firms may benefit from the imposition of a quota or tariff, the consumer welfare in the country imposing the quota or tariff declines.

2 - Relay Network Design Problem under Uncertainty

Amin Ziaeifar, Southern Methodist University, 3002, Dallas, TX, 75231, United States, Halit Uster

We investigate designing a relay network for truckload transportation with uncertain demand. We propose a new two-stage stochastic program to model the problem. We devise an enhanced L-shaped method configured to efficiently solve large-size instances having significant number of scenarios. We present a computational study to demonstrate the performance of our algorithm on different test instance classes.

3 - Reformulation-linearization Technique Formulation and Gpu Acceleration for the Multidimensional Assignment Problem

Samhita Vadrevu, University of Illinois at Urbana Champaign, Urbana, IL, United States, samhita3@illinois.edu, Rakesh Nagi

This research is focused on reformulation and parallelization of multidimensional assignment problems. Strong lower bounds are obtained with Reformulation and Linearization Technique (RLT) and a dual ascent scheme. Efficient parallel algorithms are designed to accommodate the rapidly growing number of variables and tested for large instances with single and multiple GPUs.

4 - Quantifying Network Dissimilarities

Harshitha Meda, PhD. Candidate, North Carolina A&T State University, Greensboro, NC, United States, hmeda@aggies.ncat.edu, Chrysafis Vogiatzis

Quantifying network dissimilarity is a complex problem. In this talk, we focus on a specific part of quantifying how different two networks are based on their shortest path distribution. Specifically, we employ the set of shortest paths in two ways for every node: the first, which we call betweenness divergence, reveals the distance of a node to every shortest path, while the second, which we refer to as escape distribution, shows how diversely a node leads to every other path in the network. We present the mathematical derivation of these two terms and then use them to obtain a metric of network dissimilarity. We finish the talk with a series of computational results on real-world and synthetic instances.

5 - A Branch-and-cut Method for Dynamic Monopoly Problem

Minjiao Zhang, Kennesaw State University, Kennesaw, GA, 30144, United States, mzhang16@kennesaw.edu, Babak Moazzez

Dynamic monopoly (or dynamo for brevity) models the spread of influence in the context of graph theory. We study the polyhedral structure of the dynamic monopoly polytope that arises from integer programming formulations of dynamic monopolies in graphs. We present several families of valid inequalities for two alternative formulations. Our focus is to develop efficient separation algorithms for the proposed valid inequalities and generate branch-and-cut methods to solve the dynamic monopoly problems effectively. We demonstrate the efficacy of our branch-and-cut methods by conducting comprehensive computational study.

■ MD43

CC- Room 612

Software Matters

Sponsored: Computing

Sponsored Session

Chair: Mesut Yavuz, University of Alabama, Tuscaloosa, AL, 35487, United States

Co-Chair: Huseyin Ergin, Ball State University, Muncie, IN, 47304, United States

1 - Software Engineering for Research Software

Jeffrey Carver, University of Alabama, Tuscaloosa, AL, 35487, United States, carver@cs.ua.edu

Increasingly research advances are enabled by Research Software (i.e. software that enables research in various disciplines). The characteristics of this software and the fact that the researchers who develop it are often domain experts but not necessarily software engineering (SE) experts, results in a need to understand how to identify and apply appropriate SE practices for high-quality and sustainable software. This talk focuses on work done to advance this understanding through surveys and case studies. The talk will also describe the efforts of an ongoing project to design a US Research Software Sustainability Institute (URSSI), which includes a number of workshops and a large-scale survey.

2 - A Study of Software Development Practice in Operations Research

Huseyin Ergin, Ball State University, Muncie, IN, United States, hergin@bsu.edu, Mesut Yavuz

Software is a crucial part of research in many fields today. However, software development is not an easy task. Primarily it is harder in fields where researchers are not formally trained to produce better software systematically. In this talk, we will primarily share the results of a survey we have been conducting for the last ten months. The results of the survey will shed light on the software development practice in Operations Research (OR), reveal the relationship of the OR scholars with research software, and present the expectations and concerns of them regarding code and data sharing practices.

3 - 40 Years of Operations Research Software Development: Lessons Learned

John W. Chinneck, Carleton University, Systems and Computer Engineering, Ottawa, ON, K1S 5B6, Canada, chinneck@sce.carleton.ca

Advice and hard lessons learned during 40 years of developing algorithmic software for operations research. Things to consider when embarking on a new project: programming and modelling languages, basic numerical methods, solvers, software libraries, test sets, experiment design, etc.

4 - A New Computational Optimization Framework

Mesut Yavuz, University of Alabama, Alston Hall Box 870226, Tuscaloosa, AL, 35487, United States, myavuz@cba.ua.edu, Huseyin Ergin

We present a new framework consisting of libraries enabling faster development and experimentation in computational optimization. We demonstrate the use of the framework on a parallel-machine-scheduling problem and highlight the improvements obtained from using the framework.

■ MD44

CC- Room 613

Computational Advances in Production Planning and Inventory Management

Sponsored: Computing

Sponsored Session

Chair: Kartik Kulkarni, Blacksburg, VA, 24060, United States

Co-Chair: Manish Bansal, Virginia Tech., Blacksburg, VA, 24060, United States

1 - The Role of Robustness in Inventory vs. Timeliness Trade-off in Project Delivery

Arman Jabbari, University of California-Berkeley, 715 E. 19TH ST, Berkeley, CA, 94606, United States, jabbari@berkeley.edu, Philip Kaminsky

We explore the tradeoffs between inventory holding costs and project completion times in a variety of settings, across single and multiple projects, and we analyze how robustness affects these tradeoffs.

2 - M-natural-Convexity and its Applications in Operations

Menglong Li, UIUC, 164 Paddock DR E, Urbana, IL, 61874, United States, ml10@illinois.edu, Xin Chen

M-natural-convexity, one key concept in discrete convex analysis, possesses salient combinatorial properties and finds applications in discrete systems, operations research and economics. In this talk, we illustrate how this concept and its variants can be used to develop monotone comparative statics in parametric optimization problems, the existence of nonincreasing optimal solution in parameters, which is in sharp contrast to classical results in lattice programming on nondecreasing optimal solution. We present applications in operations and demonstrate that looking from the lens of M-natural-convexity may allow one to greatly simplify some complicated analysis in the literature.

3 - Dynamic Sourcing and Learning Strategies for Food Supply Systems with Quality Risk and Limited Traceability

Zhendong Pan, Purdue University, Hawkins Hall Room 0801, 430 Wood Street, West Lafayette, IN, 47906, United States, Zhan Pang

Motivated by food quality and safety issues in food supply chains with limited traceability, we consider a single-product supply system in the presence of multiple suppliers with unknown qualities. Based on the prior belief on the quality distributions, though sourcing to high-quality suppliers may lead to higher expected rewards, sourcing to some lower-quality suppliers may yield greater prospects. We demonstrate the trade-off between exploitation and exploration in dynamic sourcing decisions and show that the optimal sourcing policy can be characterized with a class of index policies. We also identify the value of information provided by food traceability systems.

4 - Evaluating Integer Programming Models for Solving Stochastic Inventory Problems

Ton de Kok, Eindhoven University of Technology, Eindhoven, 5600 MB, Netherlands, Bas Bluemink, Balan Srinivasan, Reha M. Uzsoy

We formulate integer programming models for the solution of finite horizon periodic review capacitated stochastic inventory models. The formulations require several approximations, but computational experiments show that they can yield near-optimal solutions in modest CPU times under a range of experimental conditions.

5 - Recent Advancements for Solving Generalizations of the Classical Lot-sizing Problem

Kartik Kulkarni, Virginia Tech, Blacksburg, VA, 24060, United States, kartikrf@vt.edu, Manish Bansal

In this talk, we present our recent advances on solving generalizations of the classical single-item economic lot-sizing problem where the total production capacity in each period can be the summation of some integer multiples of several capacity modules of different sizes.

■ MD45

CC- Room 614

Large Scale and Distributed Optimization I – In Memory of Wei Shi

Sponsored: Optimization/Nonlinear Programming

Sponsored Session

Chair: Ermin Wei, Northwestern University, Evanston, IL, 60208, United States

Co-Chair: Fatemeh Mansoori, Northwestern University, Evanston, IL, 60202, United States

Co-Chair: Wotao Yin

1 - Minibatch Stochastic Subgradient-based Projection Algorithms for Solving Convex Inequalities

Angelia Nedich, ASU, Tempe, AZ, 85281, United States, Angelia.Nedich@asu.edu, Ion Necoara

We consider a convex feasibility problem where the feasible set is given as the intersection of a (possibly infinite) number of closed convex sets. We assume that each set is specified algebraically as a convex inequality, where the associated convex function is general (possibly nondifferentiable). To find a feasible point for all the inequalities, motivated by the work of B.T. Polyak, we design and analyze random projection algorithms using special subgradient iterations and extrapolated stepsizes. For the minibatch stochastic subgradient-based projection methods, we prove asymptotic convergence results and prove linear convergence rates.

2 - Flexible Distributed Gradient Methods with Stochastic Errors

Ermin Wei, Northwestern University, Tech L310, Evanston, IL, 60208, United States, Fatemeh Mansoori, Charikleia Iakovidou

One of the most important problems in the field of distributed optimization is the problem of minimizing a sum of convex objective functions over a networked system. In such a network, each agent has access to a local objective function and works toward minimizing it, using potentially noisy local information and the information from its neighbors. We develop a class of communication aware distributed methods with minimal storage requirement, which can tradeoff computation and communication costs depending on the application. We analyze their respective convergence properties.

3 - Operator Splitting Methods in Decentralized Optimization

Wotao Yin, Alibaba US, Bellevue, WA, United States, Ming Yan

Many big-data problems must be solved in a decentralized manner, which uses short-distance communication between adjacent nodes to achieve the goal of the whole network. Decentralized methods are better for data privacy and more robust to failures. This talk overviews the formulations and methods of decentralized consensus optimization through a unified framework of operator splitting. The objective is that the variables of all nodes converge to the same vector that minimizes the sum of their objective functions. Naive decentralized algorithms are order-of-magnitude slower than their centralized counterparts. Recent methods based on duality have significantly narrowed this gap.

4 - A Stochastic Gradient Descent Ascent Method for Saddle Point Problems

Alireza Fallah, Massachusetts Institute of Technology, Cambridge, MA, 02139, United States, afallah@mit.edu, Sarath Pattathil, Asuman Ozdaglar

In this work, we study the strongly convex- strongly concave saddle point problem when the exact gradient is not available, and instead, we have access to its unbiased estimate at each iteration. In particular, we focus on Gradient Descent-Ascent method (GDA) and provide a characterization of rate and robustness in the presence of noise.

■ MD46

CC- Room 615

Dynamic Traffic Assignment and Traffic Simulation

Sponsored: Transportation Science & Logistics/Intelligent Transportation Systems (ITS)

Sponsored Session

Chair: Omer Verbas, PhD, Argonne National Laboratory, Lemont, IL, 60439, United States

1 - Calibrating Large Scale Traffic Flow Simulation Models with Integrated Dynamic-Traffic-Assignment

Felipe A. de Souza, Postdoctoral Appointee, Argonne National Laboratory, Argonne, IL, United States, fdesouza@anl.gov, Omer Verbas, Joshua Auld

Commonly, traffic simulation models are calibrated based on road-specific sensors or vehicle trajectory data disregarding route-choice (DTA). We propose a simulation-based calibration technique to calibrate large-scale areas based on individual trajectories so as to (i) reproduce the individual links travel times from the observed trajectories, and (ii) no other alternative route yields significantly lower travel time to the same origin-destination than the observed route. We applied the proposed technique in the Chicago metropolitan area reaching accurate average travel times, despite larger deviation in localized areas of the network.

2 - A Distributed Gradient Approach for Cell Transmission Model-based System Optimal Dynamic Traffic Assignment

Mehrzad Mehrabipour, Washington State University, Pullman, WA, 27606, United States, mehrzad.mehrabipour@wsu.edu, Ali Hajbabaie

This study presents a distributed gradient algorithm to solve a system optimal dynamic traffic assignment problem modeled based on the cell transmission network loading concept. The algorithm distributes the problem into local sub-problems without requiring a central component. A sub-problem receives proposed values for common decision variables from all adjacent sub-problems, incorporates them with its offered values by weighted averaging, and enforces a gradient step to minimize its objective function. Then, the value is projected on the feasible region of the sub-problem. We show that the algorithm converges to the optimal solution.

3 - Traffic Flow and Speed Prediction on Freeways Using a Three-phase Model and Probe Data

Seiran Heshami, PhD. Candidate, University of Calgary, Calgary, AB, Canada, seiran.heshami@ucalgary.ca, Lina Kattan, Arash Afshar

In this research a traffic state prediction model is developed which includes two main modules: A) Online simulation, B) Data fusion and traffic state prediction. A stochastic microscopic model, based on three-phase traffic theory, is used to predict traffic flow and speed based on probe data. Predicted traffic parameters are fused with detector measurements through an Adaptive Kalman Filter to produce more accurate estimation of the traffic flow and speed for short time intervals.

4 - Ramp Meters as Control Variates for Freeway Simulations

William Alexander, University of Texas, Austin, TX, United States, Stephen Boyles

Simulation models are used extensively in transportation engineering to evaluate design changes. Previous work in variance reduction methods for roadway simulation includes common random numbers and antithetic variates. This study explores the application of control variates for variance reduction in the specific scenario of a freeway on-ramp with a ramp meter as the sole influencing control mechanism. Traffic dynamics are simulated using the cell transmission model. Using simulated arrivals and a fixed service time at the ramp meter, queueing theory provides a control variate to reduce variance and expedite the evaluation of ramp meter timing performance.

■ MD47

CC- Room 616

Information Systems VI

Contributed Session

Chair: Seul-ah Kim, Korea University, Seoul, 02841, Korea, Republic of

1 - Duopoly Pricing Strategy for Providing Digital Media Online: Subscription-only or Subscription-prior?

Jingpei Ma, Dalian University of Technology, Dalian, China, majingpei@mail.dlut.edu.cn, Wenli Li, Shuai Zhao

Many online media platforms offer prior content to subscribers, and also offer it for free with ads after a “windowing” period.This paper adopts a game theoretical approach to examine the impact of delay-ad-sponsored offering on the competition between two platforms. The platform can either offer a subscription-only strategy or a subscription-prior strategy with delay-ad-sponsored service. We will derive the market equilibria and present conditions under which the subscription-prior strategy outperforms the subscription-only strategy. We will find how the length of “windowing” period impact the platforms’ offering decisions and the equilibrium solutions.

2 - Pay as You Wish with Network Effect

Yutian Li, Assistant Professor, University of Science and Technology of China, HEFEI, China, liyutian@ustc.edu.cn, Can Sun

In this paper, we investigate the pricing strategy that are widely used by many live video stream firms. Under the pricing strategy, the audiences can pay the streamer as much as they like some of them are even watching for free. This policy is the so-called pay-as-you-wish pricing policy. On the other hand, the live video streaming exhibits network effect, which is different from pay-as-you-wish pricing literature. We find that when more people do not pay, firm’s profit may increase. We also compare the pay-as-you-wish pricing strategy with the subscription fee pricing strategy.

3 - YouTube Video Thumbnails: Do They Matter for Video Clicks?

Fuquan Cui, Korea university, Seoul, Korea, Republic of, cuifuquan0622@korea.ac.kr, Byungwan Koh

A recent AdWeek survey found 88% growth year over year in time spent watching videos on a smartphone. This high traffic on social media and video website has attracted the attention of many businesses. They extensively use social media and video website to deliver their ads, especially video ads. Consequently, how to be found and clicked among a large number of video ads available on the Internet is also gaining much attention from academia and industry. It is shown that nearly half of video ads on the Internet are, in fact, never clicked. This study investigates the impact of video thumbnails on video clicks.

4 - Optimal Platform Price Discrimination and the Measurement of Network Effects

Seth G. Benzell, Postdoctoral Associate, MIT, Cambridge, MA, United States, sbenzell@mit.edu, Avinash Collis

We propose an analytical model and practical procedure for a platform to exploit heterogeneous network effects. Using the example of Facebook, we evaluate profit maximization first order conditions. The relevant network characteristics are collected using surveys and choice experiments on a representative sample of the US online population. We find that Facebook could increase monthly profits by increasing the amount of advertising on some market segments, and decreasing it on others. Finally, we contrast the platform's profit maximizing strategy with a social welfare maximizing one.

5 - A Sampling Strategy for Unbundled Digital Contents – with a Different Quality and Price

Seul-ah Kim, Korea University, Seoul, Korea, Republic of, soelah1@korea.ac.kr, Byungwan Koh

To increase a digital content sales, three strategies can be implemented: bundling, unbundling and unbundling with sampling. This paper examines the most preferred strategy in terms of the firm's profit and customers' surplus, by restricting the distribution of the quality and the price on two unbundled contents. When the firm can change the quality and price allocation, regardless of the customer retention rate, unbundling strategy without a free sample can have an advantage over the bundling strategy. However, if the two conditions are restricted, as the sampling effect increases, the sampling strategy can have an advantage over other strategies.

■ MD48

CC- Room 617

Healthcare Operations and Medical Decision-Making

Sponsored: Manufacturing & Service Oper. Mgmt/Healthcare Operations

Sponsored Session

Chair: Pinar Keskinocak, Georgia Institute of Technology, Atlanta, GA, 30332, United States

Co-Chair: Julie L Swann, Georgia Institute of Technology, School of ISYE, Atlanta, GA, 30332-0205, United States

1 - An Agent-based Simulation for Seasonal Guinea Worm Disease in Chad Dogs

Tyler Perini, Georgia Institute of Technology, Atlanta, GA, United States, perinita@gatech.edu, Julie L. Swann, Pinar Keskinocak, Adam Weiss, Ernesto Ruiz-Tiben

One obstacle to eradicating the Guinea Worm parasite in Chad is the infections of dogs, which far outnumber human infections. We present the first agent-based simulation that models transmission between a (shared) water source and a large population of dogs. By calibrating the infectivity parameters for several different hypothetical environmental factors, we find that a combination of temperature and rainfall best explain the seasonal infections. In addition, this tool can be used to forecast the effectiveness of potential intervention schemes, in order to inform program managers of the combination of interventions that is most likely to lead to eradication.

2 - Time Well Spent: A Metric to Improve Productivity and Quality in Health Care Services

Senthil Veeraraghavan, University of Pennsylvania, Philadelphia, PA, United States, senthilv@wharton.upenn.edu

Health care productivity has generally lagged behind other services. Waiting times are long, despite the service time has reduced over time, and resources have over-utilized. Based on data, we show how electronic health records (EHRs) have not assisted in improving productivity. We propose a time-based metric to reduce non-value adding activities and resolve the quality-speed conflict. We provide recent empirical evidence.

3 - Using Stochastic Decision Making Processes to Improve Alzheimer's Disease

Saeideh Mirghorbani, Assistant Professor, Binghamton University, Vestal, NY, United States, smirghorbani@binghamton.edu, Sharif Melouk, John Mittenthal

Genetics, high blood pressure and diabetes are some of the factors that place individuals at a higher risk of developing Alzheimer's disease (AD). To manage this risk in persons more susceptible to AD, we develop a partially observable Markov decision process model for individuals transitioning through different stages of AD.

4 - An Optimization Scheme for Malaria Intervention Methods

Johnny Gillings, NC State University, Raleigh, NC, United States

Malaria is a vector borne disease that affects millions throughout the world. The global fight against Malaria has been on-going for decades, and calls to use mathematics to optimize attempts to curb the disease's spread have intensified. In this paper we develop a model for optimally allocating malaria intervention resources within regions subject to budget and feasibility constraints. The outcome of the model is an intervention plan over a given time horizon. The model finds an optimal intervention policy by taking advantage of the problem formation and, if required by the objective function, considering states from differential equations models to determine intervention effectiveness.

■ MD49

CC- Room 618

Shared Mobility Systems: Operations and Economics

Sponsored: Transportation Science & Logistics/Urban Transportation

Sponsored Session

Chair: Neda Masoud, University of Michigan, University of Michigan, Ann, MI, 48109, United States

1 - Courier Management in Crowd-sourced Food Delivery Operations

Ramon Auad, Ph. D. Student, Georgia Institute of Technology, Atlanta, GA, 30318, United States, rauad@gatech.edu, Alan Erera, Martin Savelsbergh

Recently, online restaurant aggregators with integrated meal delivery networks have substantially grown in popularity. Research efforts in this line have primarily focused on diners satisfaction. However, little research has been done on the satisfaction of couriers, also critical to guarantee the success of this business model. In this work, we additionally consider couriers' satisfaction, which we measure as the size of the region they operate in. We develop a rolling horizon policy that performs dynamic order assignments and region redefinition via bipartite matching, and show evidence of a positive effect from considering couriers satisfaction in the overall delivery operations.

2 - An Integrated Decomposition and Approximate Dynamic Programming Approach for On-demand Ride Pooling

Siqian Shen, Associate Professor, University of Michigan, Industrial & Operations Engineering, Ann Arbor, MI, 48109, United States, siqian@umich.edu, Xian Yu

Ride-pooling optimization, aiming to combine trips of multiple passenger groups with different origin-destination, is challenging and emerging. In this paper, we dynamically match available drivers to randomly arriving passengers over finite stages and also decide pick-up and drop-off routes for each driver. To solve large-scale problem instances, we develop both spatial and temporal decomposition schemes, where we solve each subproblem using Approximate Dynamic Programming (ADP) and couple the solutions. We test instances based on the New York City taxi data to show the positive impacts of pooling rides, computational efficiency of our approach, and empirical convergence of ADP.

3 - Congestion-aware Pricing on Ridesourcing: A Bayesian Optimization Approach

Qi Luo, PhD Candidate, University of Michigan, Ann Arbor, MI, United States, luoqi@umich.edu, Romesh Saigal, Zhiyuan Huang, Henry Lam

Despite the documented benefits of ridesourcing services, recent studies show that they can slow down traffic in the densest cities significantly. To implement congestion pricing policies upon those vehicles, regulators need to estimate how much their congestion effects are. This paper studies simulation-based approaches to address the two technical challenges arising from the representation of system dynamics and the optimization for congestion price mechanisms. This data-driven approach can potentially be extended to solve large-scale congestion pricing problems with unobservable states.

4 - Analyzing Ride-sourcing Systems Using a Fluid Model Framework

Zhengtian Xu, University of Michigan, Ann Arbor, MI, 48105-2540, United States, xzt@umich.edu, Yafeng Yin, Xiuli Chao, Jieping Ye

The popularisation of ride-sourcing services, such as Uber and Didi Chuxing, have attracted extensive research interests in service management. On these quests, there emerges a pressing need for a theoretical framework to capture the operational characteristics of a ride-sourcing system. With the framework, properties of the system performance can be discussed as well as controls and strategies to improve the performance. This study aims to address this need by establishing a fluid model framework. Our model closely follows the operational mechanism of a ride-sourcing system, and is leveraged to examine the system capacity as well as the efficiency of various control strategies.

■ MD50

CC- Room 619

Emerging Logistics Research

Sponsored: Transportation Science & Logistics/Facility Logistics

Sponsored Session

Chair: Lian Qi, Rutgers University, Piscataway, NJ, 08854, United States

1 - Scheduling for Order Picking in 3d AS/RS

Mingzhou Jin, University of Tennessee-Knoxville, 525D John D. Tickle Engineering Building, Industrial and Systems Engineering, Knoxville, TN, 37996, United States, jin@utk.edu, Wenquan Dong, Yanyan Wang

We focus on crane-based 3D automated storage and retrieval system (AS/RS) with shuttle-based depth movement mechanisms in this study. The optimization model focuses on the optimal assignment of shuttles, sequence of retrieval tasks and shuttle reallocation tasks. A mixed integer program is developed to minimize the cycle time for a given set of retrieval task and is proven NP-Hard. A genetic algorithm based on the feature of the problem is presented and compared to a commercial solver and the first-come first-serve rule. Numerical experiments are conducted to gain insights on the right number of shuttles.

2 - Optimal Maximum Coverage Location for Electric Vehicle Charging Stations under Uncertainty

Yue Guo, Beijing Institute of Technology, Beijing, China, guoyue16@126.com, Yuli Zhang, Ningwei Zhang, Bingjie Zhong

The deployment of electric vehicle (EV) charging stations is critical to mitigate the mileage anxiety and thus promote EV adoption. This paper considers the optimal EV charging stations location problem where charging demands are uncertain at the infrastructure planning stage. To provide robust location decisions, a two-stage distributionally robust maximum coverage location model is proposed where the uncertain demands are described by mean-covariance information. We provide an equivalent mixed 0-1 quadratic conic programming reformulation and present an efficient algorithm. Numerical experiments are conducted to validate the effectiveness of the proposed model and algorithm.

3 - Optimal Recharge Policy for Battery Electric Vehicles

Peng Li, Rutgers University, Piscataway, NJ, United States, peng.li.scm@rutgers.edu, Chunliu Zhou, Lian Qi

Recent years, Electric Vehicle (EV) has mitigated carbon emission and air pollution in many countries. However, the limited range, inconvenient recharge process and high battery cost of EV have greatly constrained customer adoptions. Although the battery exchange service can partially address these issues,how to optimize operations and reduce the high inventory cost of batteries should still be considered at each swapping station.We propose a navel policy to address these issues as follows 1) how to optimize operations and reduce the batteries inventory cost; 2) how many batteries should be stocked; and 3) how many swapping servers and charging bays should be implemented at each swapping station.

4 - A General Integer Replenishment Policy for Solving the VMI & CS Problem

Feng Liu, Dongbei Univeristy of Finance and Economics, AL, United States, drliufeng@mail.dlut.edu.cn, Ming-Jong Yao

In order to achieve maximum benefits, companies are trying to coordinate their supply chain members using various programmes. In practice, VMI and CS are often combined as a business partnership (VMI&CS). This paper focuses on the inventory management problem for a single-vendor and multiple-buyers supply chain under the VMI&CS and Centralized scenarios. It considers the vendor's setup time and assures that different buyers have different replenishment cycles following the general integer policy. A mathematical model is constructed, and the theoretical analysis on the inventory cost is carried out to design an optimal algorithm.

5 - Online Brands' Pricing and Showroom Decisions

Dincer Konur, Texas State University, San Marcos, TX, 78666, United States, d_k141@txstate.edu

In this study, we investigate two online brands' competitive pricing and showroom decisions. Equilibrium pricing and showroom decisions are characterized under sequential and simultaneous showroom expansion decisions. Then, shared showroom concept through cost- and revenue-sharing contracts is investigated. It is discussed that a brand can incentivize the other brand to share a showroom.

■ MD51

CC- Room 620

Joint Session AAS/TSL Air: Airline Coordination and Competition

Sponsored: Aviation Applications

Sponsored Session

Chair: Reed Harder, Dartmouth, Hanover, NH, 03755, United States

1 - Primary Versus Secondary Mechanisms for Infrastructure Capacity Allocation when Users are Strategic

Vikrant Vaze, Dartmouth College, Murdough Center, Hanover, NH, 03755, United States, vikrant.s.vaze@dartmouth.edu, Alexandre Jacquillat, Weilong Wang

Two broad approaches exist to cope with information asymmetries in non-monetary capacity allocation for infrastructure systems. In a primary mechanism, the infrastructure manager directly determines the schedule. In a secondary mechanism, users can swap their service units following the initial schedule determination by infrastructure manager. The secondary mechanism provides flexibility to align the schedule with users' private preferences. However, this paper develops a bi-level capacity allocation game for multi-period operations, discrete service units and non-atomistic users to show that the secondary mechanism may not result in more efficient outcomes when users are strategic.

2 - Frequency Approximations for Two-stage Location Price Competition

Reed Harder, Dartmouth, Hanover, NH, 03755, United States, reed.haseltine.harder.TH@dartmouth.edu, Vikrant Vaze

In many critical industries, competing firms allocate resources across their networks by deciding service locations and pricing these services. For example, airlines competitively schedule and price flights across many origin-destination pairs. Solving for exact equilibrium service locations and prices can quickly become intractable. However, questions of practical interest are often more concerned with aggregate quantities of service within a market than exact service location decisions. With considerations in mind, we evaluate the effectiveness of approximating location decisions with service frequency decisions in firm profit functions.

3 - Predictive Models of Entry in the United States Airline Industry

Kang Hua Cao, Assistant Professor, Hong Kong Baptist University, Kowloon Tong, Hong Kong, kanghuacao@hkbu.edu.hk, Lei Kang, Chia-Mei Liu, Vikrant Vaze

Existing aviation demand forecasting methods maintain the so-called fixed network assumption. However, ignoring strategic effects among airlines in forecasting can lead to biased results. In this paper, we develop predictive game-theoretic models of entry for the U.S. airline industry. We use the structural model to identify the parameters that represent the strategic (competition) effects by the principle of revealed preference. We apply the model to predict the probabilities involved in an airline company entering or exiting a market.

4 - Quantity - Contingent Auctions for Airport Slot Allocation

Alexander Stewart Estes, University of Minnesota, Minneapolis, MN, 55414, United States, este0100@umn.edu

We propose a new type of auction, called a quantity-contingent auction, to allocate airport arrival and departure slots. A quantity-contingent auction determines both the number of items sold and an allocation of items to bidders. Since such auctions could be used by bidders to gain excessive market power we impose constraints limiting market power. We propose a continuous model and an integer programming model for the associated winner determination problem. Using these models, we perform computational experiments that lend insights into the properties of quantity-contingent auctions when used to allocate slots at an airport.

5 - Benefits of Airline Information Sharing During Airport Ground Delay Programs

Karthik Gopalakrishnan, Massachusetts Institute of Technology, Cambridge, MA, United States, karthikg@mit.edu, Hamsa Balakrishnan

Ground Delay Programs (GDPs) are used to delay flights on the ground at their origins in order to minimize airborne delays during periods of reduced arrival capacity at their destinations. Airlines do not share flight-specific delay costs with the system operator (e.g., the FAA) due to intra-airline competition and privacy concerns. Using simulations, we quantify the loss in system efficiency due to a lack of information-sharing, for different GDP formulations that have been proposed in the literature. This lack of information sharing, while affording the airlines more privacy, is found to have a significant cost in terms of efficiency. These results motivate the study of new approaches to GDPs.

■ MD52

CC- Skagit 1

RMP Practice Prize Session

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Guillermo Gallego, Hong Kong University of Science and Technology, Academic Concourse, Hong Kong, 852, Hong Kong

1 - Pricing Analytics for Reusable Resources

Adam Elmachtoub, Columbia University, New York, NY, 10027, United States, Omar Besbes, Yunjie Sun

We describe a comprehensive approach to pricing analytics for reusable resources in the context of rotable spare parts, which are parts that can be repeatedly repaired and resold. Pricing rotables presents unique challenges ranging from limited data, minimal demand information, and complex inventory dynamics. We prove that a static pricing policy is guaranteed to achieve at least 78.9% of the optimal dynamic pricing policy, and up to 95.5% in a special, practical case. We describe a multi-year, large-scale implementation at a major aircraft manufacturer, resulting in 3.9% profit improvement.

2 - Customer Choice Models versus Machine Learning: Finding Optimal Product Displays on Alibaba

Jacob Feldman, Olin Business School, Saint Louis, MO, 63108-1291, United States

We compare the performance of two approaches for finding the optimal set of products to display to customers landing on Alibaba's two online marketplaces, Tmall and Taobao. Both approaches were placed online simultaneously and tested on real customers for one week. The first approach we test is Alibaba's current practice. This procedure embeds thousands of product and customer features within a sophisticated machine learning algorithm that is used to estimate the purchase probabilities of each product for the customer at hand. The products with the largest expected revenue are then made available for purchase. Our second approach uses a featurized multinomial logit (MNL) model to predict purchase probabilities for each arriving customer. We use historical sales data to fit the MNL model and then, for each arriving customer, we solve the cardinality-constrained assortment optimization problem under the MNL model online to find the optimal set of products to display. Our experiments show that despite the lower prediction power of our MNL-based approach, it generates significantly higher revenue per visit compared to the current machine learning algorithm with the same set of features.

3 - Demand Learning and Dynamic Pricing for Varying Assortments: Algorithm Development and Implementation at Zenrez

Kris Johnson Ferreira, Harvard Business School, Boston, MA, 02163, United States

We develop a multi-product, attribute-based demand learning and dynamic pricing algorithm that efficiently learns customer demand to maximize revenue when a small number of price changes are allowed and when products may change over time. Our algorithm follows a learn-then-earn approach, using a novel adaptation of conjoint analysis in the learning phase. We validate the effectiveness of our algorithm through a three-month field experiment with an e-commerce company (Zenrez), where we change the price of products with daily assortment changes. Relative to a control group, our algorithm led to an 8.8% increase in average daily revenue.

4 - RMP Practice Prize

Guillermo Gallego, Hong Kong University of Science and Technology, Academic Concourse, Dept. of Industrial Engr. & Logistics Mgmt, Hong Kong, 852, Hong Kong

This session will feature the finalists of the INFORMS Revenue Management and Pricing Section practice competition.

■ MD53

CC- Skagit 2

Interface of Marketing and Operations Management

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Spyros Zoumpoulis, INSEAD, Fontainebleau Cedex, 77305, France

1 - Optimization of Multi-channel Marketing Contacts

Kalyan Talluri, Imperial College Business School, United Kingdom, kalyan.talluri@imperial.ac.uk, Clint Ho, Sven Mikolon, Wolfram Wiesemann

We describe a dynamic-programming/machine-learning model to optimize marketing contacts across multiple channels that takes into account customer lifetime value, marketing costs and contact effectiveness. We describe implementation experience at a large telecommunications firm.

2 - Learning Targeting Models under Concept Shift

Spyros Zoumpoulis, INSEAD, Boulevard de Constance, Decision Sciences Area, Fontainebleau, 77305, France, spyros.zoumpoulis@insead.edu, Theodoros Evgeniou, Duncan I. Simester, Artem Timoshenko

A prominent challenge when using machine learning to target marketing actions to different customers is non-stationarity. We focus on concept shift - a form of non-stationarity that involves changes in the customer response function over time. We develop theoretical results on the learnability of targeting models under concept shift, and we develop practical targeting algorithms that perform well in practice. Overall, our findings characterize conditions on non-stationarity under which firms can train targeting models that perform well.

3 - Product Driven Questionnaire Design for Assortment Optimization

Jonathan Z. Amar, Massachusetts Institute of Technology, Cambridge, MA, 02139, United States, amarj@mit.edu, Nikolaos Trichakis, Chaithanya Bandi

We develop a novel question-design mechanism in order to improve healthcare plan recommendations. Our algorithm is based on accurately estimating the differences of utilities associated with every plan. Rather than being agnostic to it, our formulation is driven by available assortment, and therefore achieves better performance for plan recommendation. We establish theoretical justification for our algorithm which outperformed state-of-the-art methods on real datasets.

■ MD54

CC- Skagit 3

New Directions for Experimentation and Learning in OM

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Yonatan Gur, Stanford University, Stanford, CA, 94305, United States

1 - Sample-Based Optimal Pricing

Omar Besbes, Columbia University, Graduate School of Business, New York, NY, 10027, United States, ob2105@gsb.columbia.edu, Amine Allouah

Pricing is central to many industries and academic disciplines ranging from Operations Research to Computer Science and Economics. In the present talk, we will focus on data-driven optimal pricing in low informational environments. We analyze the fundamental problem of how to optimally price based on a single sample of the willingness-to-pay (WTP) of customers. The decision-maker's objective is to select a general pricing policy with maximum competitive ratio when the WTP distribution is only known to belong to some broad set. We characterize optimal performance across a spectrum of non-parametric families of distributions, α-strongly regular distributions.

2 - Adaptive Sequential Experiments with Unknown Information Flows

Ahmadreza Momeni, Stanford University, Stanford, CA, 94305, United States, amomenis@stanford.edu

We introduce a new, generalized multi-armed bandit (MAB) formulation in which additional information on each arm may appear arbitrarily throughout the decision horizon, and study the impact of such information flows on the achievable performance and the design of efficient policies. By obtaining matching lower and upper bounds, we characterize the (regret) complexity of this family of problems as a function of the information flows. We introduce an adaptive exploration policy that, without any prior knowledge of the information arrival process, attains the best performance that is achievable when the information arrival process is a priori known.

3 - Hedging the Drift: Learning to Optimize under Non-stationarity

Ruihao Zhu, Massachusetts Institute of Technology, Cambridge, MA, 02139, United States, rzhu@mit.edu, David Simchi-Levi, Wang Chi Cheung

We introduce general algorithms with state-of-the-art dynamic regret bounds for non-stationary bandit settings. Our main contribution is a general algorithmic recipe that first converts the rate-optimal Upper-Confidence-Bound algorithm for stationary bandit settings into a tuned Sliding Window-UCB algorithm with optimal dynamic regret for the corresponding non-stationary counterpart. Boosted by the novel bandit-over-bandit framework, it even permits us to enjoy, in a parameter-free manner, the (nearly) optimal dynamic regret. We further conduct extensive numerical experiments on the CPRM-12-001: On-Line Auto Lending dataset to show their superior dynamic regret performances.

4 - Towards Instance-optimal Regret in Online Learning

Varun Gupta, University of Chicago, Chicago, IL, United States, Marco Molinaro

The field of online learning and prediction is a rich area of research, with numerous performance metrics which aim to refine the classical notion of regret against a single best action/prediction. There is much less work on an axiomatic approach to defining optimal learners when the environment is non-stationary. In this talk we will discuss our first attempt at this problem for the task of online sequential prediction.

■ MD55

CC- Skagit 4

Revenue Management and Market Analytics IV

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Gabriel Weintraub, Stanford Graduate School of Business, Stanford, CA, 94304, United States

1 - Crowdsourcing Food Recovery Operations: A Platform Design Study

Vahideh Manshadi, Yale University, New Haven, CT, 06511, United States, vahideh.manshadi@yale.edu, Scott Rodilitz, Irene Yuan Lo

Over 60 billion tons of food goes to waste in the U.S. each year, while 40 million people—including 6.5 million children—live in food-insecure households. This mismatch is driven in part by the cost of last-mile transportation required to recover perishable food from local restaurants and grocery stores. In recent years, online platforms have emerged to facilitate crowdsourcing food recovery through volunteer or paid labor. In collaboration with one such platform, we aim to study and improve design decisions that influence the efficiency as well as the growth of the system, which crucially depends on volunteer engagement.

2 - Incentivizing Commuters to Carpool: A Large Field Experiment with Waze

Maxime Cohen, McGill University, Montreal, QC, 10012, Canada, maxccohen@gmail.com, Michael-David Fiszer, Avia Ratzon, Roy Sasson

What factors can persuade commuters to carpool? We run a field experiment on more than half a million users to encourage commuters to carpool using the Waze carpool service. Specifically, we investigate to what extent highlighting the commute time reduction (by using the HOV lane) is an effective incentive. We find that mentioning the HOV lane increases the click-through rate and conversion rate by 133-185% and 64-141%, respectively relative to a generic message. Our results ultimately suggest that users are more reactive to a commute time reduction than to earning compensation.

3 - SKU Proliferation: High-dimensional Choice Models and Online Retailing

Zoey Jiang, University of Michigan, Ann Arbor, MI, 48104, United States, jiangzh@umich.edu, Jun Li, Dennis Zhang

Online retailers are managing a great variety of products under vastly diversified consumer decision journeys. To improve retail pricing decisions, we need to understand the realistic substitution patterns among tons of products offered in the complex online environment. To address this challenge, we develop large-scale choice models that are not only scalable but also allow for flexible substitution patterns by leveraging customer clickstream information as well as econometric and machine learning methods.

4 - How Do Price Promotions Affect Customer Behavior on Retailing Platforms? Evidence from a Large Randomized Experiment on Alibaba

Dennis Zhang, Washington University in St Louis, St Louis, MO, 63130, United States, denniszhang@wustl.edu, Hengchen Dai, Lingxiu Dong

Dynamic pricing through price promotions has been widely employed by online retailers. We study how a promotion strategy—offering customers a discount for products in their shopping cart—affects customer behavior in the short and long term on a retailing platform. We conducted a randomized field experiment involving more than 100 million customers and 11,000 retailers with Alibaba Group, the world's largest retailing platform.

■ MD56

CC- Skagit 5

Nonprofit Operations Management: Focus on Resource Management

Sponsored: Public Sector OR

Sponsored Session

Chair: Telesilla Kotsi

Co-Chair: Alfonso J. Pedraza-Martinez, Indiana University, Bloomington, IN, 47405, United States

1 - Volunteers and Paid Workers in a Nonprofit Operation: Trade-offs and Social Outcomes

Lei Li, Purdue University, West Lafayette, IN, United States, leili2851@purdue.edu, Gemma Berenguer

A nonprofit organization offers activities run by workforce that can be composed of a mix of volunteers, part-time and full-time workers. We study this setting by designing a finite-horizon staffing problem to derive the organization's optimal hiring and assignment decisions. Our goal is to understand the key trade-offs between the three different type of workers and how our decisions impact social outcome. We demonstrate that a state-dependent hiring policy for part-time workers can be convenient and optimal under some conditions. We find that the budget has a significant impact on staff assignment policies, and we suggest useful heuristic policies.

2 - Improving Outcomes in Childcare Subsidy Voucher Programs Through Strategic Resource Allocation

Priyank Arora, University of Massachusetts-Amherst, Amherst, MA, 01003, United States, parora@isenberg.umass.edu, Senay Solak, Wei Wei

Childcare Resource and Referral Agencies (CCR&Rs) are tasked by the state governments with improving outcomes of childcare subsidy voucher programs. We analyze the optimal allocation of CCR&R's resources between outreach and engagement activities (with respect to childcare providers) to achieve socially-optimal outcomes across different regions in its service area.

3 - Allocation of Nonprofits' Funds Among Program, Fundraising, and Administration

Telesilla O. Kotsi, Kelley School of Business, Indiana University, Bloomington, IN, 47401, United States, tkotsi@indiana.edu, Goker Aydin, Alfonso J. Pedraza-Martinez

Nonprofits allocate their budget among three types of expenses: program spending to deliver services to beneficiaries; fundraising spending to raise donations; and administration spending to build infrastructure. We analyze how a nonprofit can balance the immediate reward of program spending versus the future reward of fundraising and administration spending. We complement our findings with a case study on foodbanks.

4 - Daily Tutor Scheduling Support at Hopeful Journeys Educational Center

Lucas A. Waddell, Assistant Professor of Mathematics, Bucknell University, Lewisburg, PA, United States, law038@bucknell.edu, Matthew D. Bailey

Hopeful Journeys Educational Center is a non-profit school whose mission is to "provide quality and individualized education to children with autism spectrum disorders and other developmental disabilities." This individualized education is implemented through hour-by-hour one-on-one scheduling of tutors to students five days a week. We present our optimization-based open-source decision support system discussing both the necessary formulation and implementation issues addressed. This DSS is in daily use and has reduced the daily scheduling process by over six hours.

■ MD57

CC- Yakima 1

Applied Advances in the Field of Emergency Response II

Sponsored: Public Sector OR

Sponsored Session

Chair: Pieter van den Berg, RSM, RSM, Rotterdam, 3062 PA, Netherlands

Co-Chair: Jordan Srour, Lebanese American University, Beirut, 1102 2801, Lebanon

1 - Fire Truck Relocation During Major Incidents

Robert van der Mei, CWI & Vu University, Science Park 123, Amsterdam, 1098XG, Netherlands, Dmitrii Usanov, Peter van de Ven, Guido Legemaate

We propose an algorithm to compute the optimal relocations of idle fire trucks needed in order to regain good coverage in case of a major fire incident with many fire trucks involved. The algorithm makes relocations by solving a mathematical program that takes into account the location of the available fire trucks and the historic spatial distribution of incidents. We apply the algorithm to the operations of the Fire Department of Amsterdam-Amstelland. We demonstrate a substantial improvement over current practice, and show that not relocating during major incidents, or relocating based on flawed heuristics and intuition, may lead to significant performance degradation.

2 - Artificial Intelligence Techniques for Ambulance Travel Time Prediction

Abbas Tarhini, Lebanese American University, Beirut, Lebanon, Abbas.Tarhini@lau.edu.lb

In emergency medical services (EMS), a fraction of the response time is the time from the dispatch of an ambulance to its arrival at the scene of an emergency. A recognised problem of this domain is the assignment of ambulances from stations in a way that the travel time to the emergency scene is minimised. The purpose of this work is to propose artificial intelligence techniques based on artificial neural network to predict the travel time of ambulances from different stations to the emergency scene. The neural network is trained and tested with data sampled from ambulances run in Lebanon. Results are compared with those of another supervised machine-learning algorithm, Bayes classification algorithm.

3 - Improving Ambulance Coverage in a Mixed Urban-rural Region in Norway

Pieter van den Berg, RSM, Erasmus University, Burgemeester Oudlaan 50, Rotterdam, 3062 PA, Netherlands

In mixed urban-rural areas, this optimization of the ambulance distribution typically involves a trade-off between backup coverage in high-demand urban areas and single coverage in low-demand rural areas. This study applies the well-studied MEXCLP to a mixed urban-rural ambulance region in Norway to investigate how the optimal distribution of ambulances depends on the workload of the system. The results show that certain rural areas should only be covered if the workload allows to shift focus from back-up coverage in the urban areas towards single coverage in rural areas.

■ MD58

CC- Yakima 2

Political Redistricting and Public Policy

Emerging Topic: Policy & Government

Emerging Topic Session

Chair: Rahul Swamy, Champaign, IL, 61820, United States

1 - Airline Baggage Fees and Flight Delays

Pritha Dutta, University of Massachusetts-Amherst, Amherst, MA, 01002, United States, Amirhossein Alamdar Yazdi, Adams Steven

We examine the linkages between the implementation of baggage fees and late flights in the airline industry. We find that baggage fees policies result in improvements in ontime performance as assessed through late flights, directly through improvements in airport-side sorting and loading efficiencies, and indirectly through lower air travel demand. We further find that these relationships are contingent upon the presence of a hub airport on a route. Our findings have important managerial and public policy implications as baggage fees have often been cited as a driver of security queue, aircraft alley, and overhead bin congestion, and ultimately delayed flights.

2 - Redistricting in Virginia

Robert Hildebrand, Virginia Tech, Blacksburg, VA, 24061, United States, rhil@vt.edu, Peter Sforza, Laurel E. Travis, Nicolas Goedert, Matthew S. Pierson

Optimal redrawing of legislative districts is inherently multi-objective. Mandated criteria vary by state, but can include equal population, compactness, contiguity, and compliance with the Voting Rights Act. It can often be a challenge to define these criteria mathematically. Most notably, compactness has many different formulations, which may have a partisan bias. Various metrics have been used to judge whether a state's redistricting plan is the product of gerrymandering. We examine inherent bias in optimizing metrics, such as compactness measure, on partisan outcomes.

3 - Contiguity Constraints in Geographic Districting

Douglas M. King, University of Illinois at Urbana-Champaign, Urbana, IL, 61801, United States, Sheldon H. Jacobson, Edward C. Sewell

Geographic districting is often formulated as a graph partitioning problem. Each partite set corresponds to the geographic area composing a single district, which must typically be contiguous. This talk discusses how the geo-graph framework for districting can be used to efficiently enforce these contiguity constraints during local search.

4 - Using Simulated Annealing to Maximize Compactness of Congressional Districts in South Carolina

Blake Splitter, Clemson University, Clemson, SC, United States, bsplitt@clemson.edu

Ensuring that congressional districts are "compact" is of paramount importance for most states in the US. In particular, South Carolina's constitution requires that congressional districts be compact. In this presentation, we use simulated annealing to generate maps that seek to optimize Polsby-Popper compactness and other measures, subject to contiguity and population constraints while considering political boundaries. Understanding how compact a state's congressional districts could be might be valuable evidence in determining whether the state is gerrymandered or not.

5 - Transparency vs Fairness in Political Redistricting

Rahul Swamy, University of Illinois at Urbana-Champaign, Urbana, IL, 61801, United States, rahulswa@illinois.edu, Douglas M. King, Sheldon H. Jacobson

Political redistricting using fairness objectives has been an upcoming topic of interest. Prior research using optimization algorithms have studied this problem in a multi-objective setting. The presented work analyzes the extreme outcomes resulting from an optimization algorithm that focuses on one particular objective. A case study on congressional redistricting is presented, that highlights the need transparency in redistricting algorithms in addition to fairness considerations.

■ MD58a

CC- Chelan 1

4:30-5:15 FICO® Xpress
5:15-6:00 MathWorks

Vendor Tutorial

1 - End-to-End FICO® Xpress Insight Tutorial: From Data to Decisions for Non-Technical Business Users

James T. Williams, FICO, 2665 Long Lake Rd, Building C, Roseville, MN, 55113, United States

You have a team with a great analytics background. They've developed advanced analytical tools using Python, R, or your current optimization solver. They've derived crucial insights from your data and figured out how your decisions shape your customers' behaviors. Now it's time to put these critical analytical insights into the hands of your non-technical business users. In this tutorial, you'll learn how FICO's Xpress Optimization solutions (including Xpress Mosel, Xpress Workbench, Xpress Solver and Xpress Insight) make it possible to embed your analytic models in business user-friendly applications. See how to supercharge your analytic models with simulation, optimization, reporting, what-if analysis, and agile extensibility for your ever-changing business. Plus, you'll discover how to use the new View Designer to reduce GUI development times from minutes to seconds.

2 - Building Optimization Applications with MATLAB

Mary C. Fenelon, MathWorks, 3 Apple Hill Dr., Natick, MA, 01760-2098, United States

MATLAB makes it easy to build optimization applications that can be deployed royalty-free as standalone executables or as web apps. In this tutorial you will learn how to work with and clean Big Data, train machine learning models from that data, specify optimization models with an algebraic syntax, and build a web app that returns optimal decisions from the predicted outcomes.

■ MD59

CC- Chelan 2

Joint Session QSR/Practice: Academic Job Application and Interview Process

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Mohammed Shafae, University of Arizona, Tucson, AZ, 85721, United States

Co-Chair: Ahmed Aziz Ezzat, Rutgers University

Moderator

Mohammed Shafae, The University of Arizona, Tucson, AZ, 85721, United States

Panelists

- Eileen Van Aken, Virginia Tech, Blacksburg, VA, 24061, United States
- Xiaolei Fang, North Carolina State University, Raleigh, NC, 27607, United States, xfang8@ncsu.edu
- Michelle M. Alvarado, Assistant Professor, University of Florida, Gainesville, FL, 32611-6595, United States, alvarado.m@ufl.edu
- Ahmed Aziz Ezzat, Assistant Professor, Rutgers University, New Brunswick, NJ, 77840, United States

■ MD59a

CC- Chelan 3

Finance Student Paper Competition

Sponsored: Finance

Sponsored Session

Chair: Agostino Capponi, Columbia University, New York, NY, 10027, United States

1 - Section on Finance Student Paper

Agostino Capponi, Columbia University, New York, NY, 10027, United States

Finalists for the Section on Finance Student Paper contest will present their papers. Papers have been accepted based on quality and originality of research.

■ MD60

CC- Chelan 4

QSR International Activities II: Machine Learning Methods in Smart Manufacturing

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Marco Grasso, Italy

Co-Chair: Xiaolei Fang, NC, United States

Co-Chair: Xiao Liu

1 - Using Neural Networks in Condition Monitoring and Process Control

Nan Chen, National University of Singapore, Department of Industrial and System Eng, 1 Engineering Drive 2, Singapore, 117576, Singapore, isecn@nus.edu.sg, Rui Wang

In this talk, we introduce a few examples where we apply the deep learning approaches, particularly the convolutional neural networks, in various applications in condition monitoring and process control with complex data structures. We mainly discuss the characteristics of the data, and how to transform them meaningfully to suit the CNN architecture. Comparisons with other approaches are also carried out to demonstrate the effectiveness.

2 - Bayesian Cross Product Process Monitoring via Transfer Learning

Kai Wang, HKUST, Hong Kong, kwangai@connect.ust.hk, Fugee Tsung, Zhenli Song

Process control is essential for high quality. The traditional SPC, however, fails often in modern high-variety industrial cases since process data of one product become scarce. To solve this small data challenge, a novel Bayesian cross-product process monitoring scheme is proposed. In particular, a joint prior distribution is used to model the relatedness between similar products, through which information can be transferred between domains. The posteriors are derived in closed forms which lead to calculation efficiency for online monitoring. A user-specified parameter is also provided to enable a better understanding of transferability issue and a free control of transferred information.

3 - A Machine Learning Method for Tool Wear Evaluation

Luca Pagani, Huddersfield University, Huddersfield, United Kingdom, L.Pagani@hud.ac.uk, Paolo Parenti, Salvatore Cataldo, Massimiliano Annoni, Scott James Scott

Indirect classification of the tool wear based on chips' color allows fast detection of out of control parts. In this paper an artificial neural network able to monitor the condition of the tool is proposed. The algorithm takes as input the color histograms of the chips, the network is then trained in order to detected high tool's wear conditions.

4 - Integrating Pre-existing Knowledge to Improve Machine Learning for Additive Manufacturing Through a Graph-based Approach

Hari P.n. Nagarajan, Doctoral Student, Tampere University, Tampere, Finland, Hossein Mokhtarian, Suraj Panicker, Eric Coatanéa, Karl R. Haapala

Additive manufacturing (AM) serves as a melting pot of variables and data for machine learning to thrive. However, machine learning based models are case-specific black box models, which lack interpretability and require extensive testing and experimentation to represent a holistic system perspective. Integrating pre-existing domain knowledge would enable transparent and cost-effective development of grey-box machine learning models. This talk presents dimensional analysis conceptual modeling framework (DACM) framework as a graph-based tool for knowledge integration and a precursor for implementation of artificial neural networks and Bayesian networks for AM process modeling.

5 - Sieve Estimation for Warranty Data

Zhisheng Ye, National University of Singapore, Singapore, Yudong Wang

Product return data are usually subject to two layers of right censoring. The first layer applies to the product lifetime due to a fixed warranty limit. The second layer applies to the sum of the sales lag and the lifetime due to the end-of-study date for the data collection. This study develops a generic method for the two-layer censored data using acyclic phase-type distributions (APHDs) in the canonical form. Based on the property that the class of APHDs is closed under convolution, a dedicated expectation-maximization algorithm is proposed for parameter estimation. Two real examples are used to illustrate the proposed method.

■ MD61

CC- Chelan 5

Data-Driven Design and Computer Simulations

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Wenbo Sun, University of Michigan, Ann Arbor, MI, 48104, United States

1 - Robust Experimental Designs for Model Calibration

Arvind Krishna, Georgia Institute of Technology, Atlanta, GA, 30318, United States, Roshan V. Joseph, Shan Ba, William Brenneman, William Myers

A physics-based model can be used for predicting an output only after specifying the values of some unknown constants known as calibration parameters. The unknown calibration parameters can be estimated from real data by conducting physical experiments. This paper presents an approach to optimally design such a physical experiment by taking advantage of the information contained in the physics-based model. The main feature of the proposed design is that although it uses the physics-based model for its construction, it is to some extent robust to potential model biases.

2 - Simulation Parameter Calibration with Adaptive Stochastic Gradient Descent

Bingjie Liu, PhD Student, University of Michigan, Ann Arbor, MI, 48105, United States, bingjiel@umich.edu, Xubo Yue, Eunshin Byon, Raed Kontar

Parameter calibration is one of the widely used techniques to improve the performance of simulation model. We cast the problem into the stochastic optimization framework and provide its solution procedure based on the stochastic gradient descent approach. In particular, we apply the variance reduction technique to reduce the computational time. The estimation performance is validated through numerical examples and case study.

3 - BDRYGP: A New Gaussian Process Model for Incorporating Boundary Information Presenter

Liang Ding, HKUST, Academic Building Room 5568, Clear Water Bay, Kowloon, Hong Kong, China, ldingaa@connect.ust.hk

Gaussian processes (GP) are widely used for surrogate modeling, but existing GP methods largely ignore boundary conditions of the underlying system. We propose a new Boundary-Conditioned Gaussian process (BCGP) model, which integrates boundary conditions within GP modeling via a product Brownian bridge correlation function. This offers two important theoretical advantages for our model. First, the equivalence between BCGP and a specific Finite Element Method leads to matrix-free computation for the model. Second, the BCGP emulator enjoys convergence rates O(n-1) for fixed dimension. These greatly improve upon existing GP performance which neglect boundary conditions.

4 - Computer Model Calibration with Low Resolution Field Data and High Resolution Experimental Data

Wenbo Sun, Research Fellow, University of Michigan, Ann Arbor, MI, 48104, United States, sunwbgt@umich.edu, Matthew Plumlee

Computer simulations are commonly used to predict responses of physical systems. When simulation models are not accurate, physical experimental data are introduced to calibrate these simulation models. However, physical experimental data are often limited due to resources' constraints and give rise to low calibration performances. In this presentation, we will discuss the case when in addition to the physical experimental data, more noisy field test data but of a greater sample size are collected. We will show the effectiveness of introducing the field test data to the calibration problem. Both a numerical example and a case study in the vehicle safety application will be provided.

■ MD62

CC- Tahoma 1

Applied Health Research by Bonder Scholars

Sponsored: Health Applications

Sponsored Session

Chair: Justin J. Boutilier, University of Wisconsin-Madison, Madison, WI, 53706, United States

1 - Optimizing Treatment Decisions under Strategically Reported Symptoms

Gian-Gabriel P. Garcia, University of Michigan, Ann Arbor, MI, 48105, United States, garciagg@umich.edu, Mariel Sofia Lavieri, Steven Broglio

Doctors rely on a broad range of information to assess patients' health and determine which treatments a patient should receive. A major challenge for doctors is to properly interpret subjective information - such as self-reported symptoms - when making treatment decisions. We model the patient's and doctor's dynamic decision problems as a multi-agent partially observable Markov Decision Process (mPOMDP). We derive structural properties of the mPOMDP and characterize its optimal policy. Then, we apply the mPOMDP to return-to-play decisions for patients with concussion.

2 - Proportionally Fair Organ Allocation Rules

Farhad Hasankhani, Clemson University, Clesmon, SC, United States, fhasank@g.clemson.edu, Amin Khademi

In this study we propose a new fairness measure into organ allocation rules and provide insights about the optimal policy with respect to this measure. We apply several policies and compare the results in terms of efficiency and fairness via a validated simulation model for heart transplantation.

3 - Ambulance Emergency Response Optimization in Developing Urban Centers

Justin J. Boutilier, University of Wisconsin-Madison, Madison, WI, 53706, United States, Timothy Chan

The lack of emergency medical transportation is viewed as the main barrier to the access and availability of emergency medical care in low and middle-income countries (LMICs). In this paper, we combine machine learning models with a robust optimization approach to determine both the location and routing of emergency response vehicles, accounting for uncertainty in travel times and spatial demand characteristic of LMICs. We then evaluate our solutions and provide an in-depth investigation into policy-related questions using a simulation model based on real data from Dhaka, Bangladesh.

4 - Risk-sharing Agreements For New Medical Treatments

Ozge Yapar, Indiana University, Bloomington, IN, United States, Stephen E. Chick, Noah Gans

Any estimate of a new treatment's value that relies only on clinical-trial data can have significant residual uncertainty. Post-marketing data, captured after the treatment has entered the market, can augment clinical-trial data to better validate the safety, efficacy, and economic value of the treatment. In fact, new risk-sharing contracts, in which a treatment's price is a function of post-marketing data, are under consideration around the world. We analyze several types of agreements that update the price according to a range of contract terms. An understanding of the equilibrium outcomes of different types of agreements is valuable to payers as they decide which contract forms to offer.

■ MD63

CC- Tahoma 2

Joint Session HAS/MIF/Practice Curated: Causal inference and Applications in Healthcare

Sponsored: Health Applications

Sponsored Session

Chair: Gabriel Zayas-Caban, Madison, WI, 53706-1691, United States

Co-Chair: Toyya Pujol

1 - Almost Exact Matching for Causal Inference

Cynthia Rudin, Duke, LSRC, Durham, NC, 27708, United States

I will describe new matching algorithms for causal inference that match treatment and control units almost exactly, meaning that matches are made using as many covariates as possible. Machine learning on a training set is used to learn the distance metric for matching.

2 - Robust Statistical Learning Methods for Difference-in-Differences Designs

Toyya Pujol, Georgia Institute of Technology, Atlanta, GA, United States, pujol@gatech.edu, Sherri Rose

Typical methods for difference-in-differences (DID) analyses rely on parametric statistical models. Our project extends statistical machine learning methods to target a DID parameter while: considering a larger nonparametric model space that makes fewer assumptions and accounting for nuances commonly found in health care research questions. We develop this framework for healthcare DID designs that also allows researchers to estimate causal/statistical effect quantities using double robust machine learning. The method is demonstrated in simulation settings and a health care policy application estimating the effect of an episode-based bundled payment program on perinatal spending.

3 - Identification in Missing Data Models Represented by Directed Acyclic Graphs

Ilya Shpitser, John C. Malone Assistant Professor, Johns Hopkins University, Baltimore, MD, United States

Missing data is a pervasive problem in data analyses, resulting in datasets that contain censored realizations of a target distribution. Many approaches to inference on the target distribution using censored observed data, rely on missing data models represented as a factorization with respect to a DAG. We consider the identifiability of the target distribution within this class of models, and show that the most general identification strategies proposed so far retain a significant gap. To address this gap, we will describe a new algorithm that significantly generalizes the types of manipulations used in the ID algorithm, developed in the context of causal inference.

4 - Impact of Treatment Time on the Risk of Emergency Department Admission Decisions and Patient Outcomes

Gabriel Zayas-Caban, University of Wisconsin-Madison, Mechanical Engineering Building, Madison, WI, 53706-1691, United States, zayascaban@wisc.edu, Sebastian Alvarez Avendano, Amy Cochran, Keith Kocher, Brian Patterson

We address the question of how to optimize patient outcomes in a decision-making scenario using causal inference in a latent variable setting. We approach this question by controlling the patient treatment, which affects the decision to admit or discharge a patient over time. We examine which adjustments optimize a patient's outcome. We then analyze the impact of optimized adjustments on patient flow in the Emergency Department.

■ MD64

CC- Tahoma 3

Emerging Topics in Healthcare Operations and Policy

Sponsored: Health Applications

Sponsored Session

Chair: Can Zhang, Duke University, Durham, NC, 27708, United States

1 - Personalized Models for Precision Heparin Dosing

Yonatan Mintz, Georgia Tech, Atlanta, GA, 30308, United States, ymintz@gatech.edu, Eva Lee

Finding optimal dose levels for time sensitive drugs such as heparin is crucial for avoiding adverse health effects. Computing these heparin doses for patients is particularly challenging since the concentration of heparin in the blood cannot be measured directly and the rates at which patients metabolize it vary greatly between individuals. In this talk we design a personalized framework for optimizing heparin doses. Using a pharmacokinetic model, we infer the current concentration of heparin and predict future therapeutic effects. We validate the predictive capabilities of our model against existing machine learning techniques and show how it can be used to optimize patient dosing.

2 - Pricing, Quality and Competition at On-demand Healthcare Service Platforms

Yixuan Liu, University of Texas, Austin, TX, 78705, United States, yixuan.liu@utexas.edu, Xiaofang Wang, Stephen M. Gilbert, Guoming Lai

We develop a strategic queueing model to study the strategic decisions of the parties at an on-demand healthcare platform. The platform decides the commission rate upon which potential doctors make their participation, service quality and pricing decisions and potential patients make their service acquisition decisions independently. We find that a higher commission rate always lowers doctor participation and service quality but may increase the service price. When the quality sensitivity of the patients increases, the service quality improves, accompanied with a higher price. Allowing the platform to control the service price may result in higher participation, higher quality and price.

3 - Incentive Mechanism Design for Patient Switching in Hospital Queuing Systems

Xinghao Yan, University of Toledo, 2801 W. Bancroft Street, Toledo, OH, 43606, United States, Xinghao.Yan@UToledo.edu, Hui Zhao, Guodong Pang

Effective use of doctor resources, especially specialized doctor resources, allows hospitals provide high-quality care to patients. However, hospitals in China experience high levels of inefficiency in the use of specialized doctors. While high levels of congestion are observed in the queues of specialized doctors, there are not enough patients in the general doctors' queues. However, not all patients in the queues of specialized doctors actually need to visit the specialized doctors. In this study, we design the incentive mechanism for the hospital to encourage patients to switch from the queue of specialized doctors to that of general doctor so as to achieve the optimized system utility.

4 - Risk-sharing Agreements for New Medical Treatments

Ozge Yapar, Indiana University, Wharton School of Business, Bloomington, IN, 19103, United States, oyapar@iu.edu, Stephen E. Chick, Noah Gans

Any estimate of a new treatment's value that relies only on clinical-trial data can have significant residual uncertainty. Post-marketing data, captured after the treatment has entered the market, can augment clinical-trial data to better validate the safety, efficacy, and economic value of the treatment. In fact, new risk-sharing contracts, in which a treatment's price is a function of post-marketing data, are under consideration around the world. We analyze several types of agreements that update the price according to a range of contract terms. An understanding of the equilibrium outcomes of different types of agreements is valuable to payers as they decide which contract forms to offer.

■ MD65

CC- Tahoma 4

Analytics for Healthcare Decision Making

Sponsored: Health Applications

Sponsored Session

Chair: Rema Padman, Carnegie Mellon University, Pittsburgh, PA, 15213, United States

1 - Can We Improve Timely Prediction of Stroke Diagnosis?

Min Chen, Florida International University, Miami, FL, United States, mchen2@fiu.edu, Rema Padman, Tan Xuan, Macickova Jana, Manjiri Kshirsagar, Ashita Vadlamudi

Timely and accurate prediction of prevalent acute diseases such as stroke can significantly reduce health care spending and improve patient outcomes. This study explores whether and how we can improve our ability to distinguish between stroke and stroke-like conditions ("stroke mimics") at hospital admission.

2 - Predicting the Risk of Surgery in Patients with Small Bowel Crohn's Disease

Mohammad Samie Tootooni, Mayo Clinic, Rochester, MN, 55906, United States, tootooni.mohammad@mayo.edu, Narges Shahraki, Benjamin Voss, Joel Fletcher, David Bruining, Mustafa Y. Sir, Kalyan Pasupathy

Crohn's Disease (CD) is one of the most prevalent inflammatory bowel diseases. We develop a logistic regression model to predict near-term surgical risk in patients with small bowel CD. The data is from 85 patients (42% female), who were treated at Mayo Clinic, Rochester, MN. Age, Harvey Bradshaw index, max mural thickness, presence of anastomosis, and multiple strictures are predictive of near-term surgical risk. The overall prediction accuracy on the validation se6t is 75% and AUROC is 0.73. This model can inform personalized treatment strategies in the management of small bowel CD.

3 - Readmission Risk Factors of CABG Surgery: Role of Surgeon and Hospital Workload

Indranil R. Bardhan, The University of Texas at Austin, Plano, TX, 75025, United States, indranil.bardhan@mccombs.utexas.edu, Jiongyun Li

We examine two critical drivers of outcome variation associated with CABG surgeries, namely hospital and surgeon cumulative workload. Drawing on data sets from Dallas Fort Worth Hospital Council and the Texas Quality Initiative, we study patient-level CABG surgeries among all patients in North Texas during a three-year period from 2011 to 2014. We find that hospital and surgeon volume are negatively associated with patient health outcomes. specifically 30-day readmission risk and frequency. Our research is one of the first studies to identify factors associated with readmission risk of CABG patients, based on data from patient visits across multiple hospitals in a large geographic region.

4 - Dynamic Classification of Rapid Progression of Glaucoma Using Supervised Machine Learning

Isaac A. Jones, University of Michigan, Ann Arbor, MI, 48141, United States, isaacaj@umich.edu, Mark P. Van Oyen, Christopher A. Andrews, Mariel Sofia Lavieri, Joshua D. Stein

To prevent vision loss, our method predicts if a patient with Glaucoma (OAG) at time t is about to experience an episode of rapid progression (RP) in the near future. RP classification is based on the predicted likelihood of progression from a current visit time t, through a follow-up window ending at year t+Y. RP was defined as a decrease of at least -1 dB/year loss in mean deviation (MD) indicated by linear regression. We developed a soft voting ensemble classifier with an ROC of 0.82 for classifying RP events over a window of the next 2 years with similar results for 3 years.

5 - Predicting Post-Surgical Complications

Rema Padman, Carnegie Mellon University, H. John Heinz III College, Mgmt Sci & Healthcare Informatics, Pittsburgh, PA, 15213, United States, rpadman@cmu.edu, Urmila Ravichandran, Jennifer Grant, Philip Prosapio, Nirav Shah

Early prediction of which patients are at increased risk of differing categories of postoperative complications can limit unnecessary testing and antibiotic prescribing and facilitate appropriate interventions. We apply multi-trajectory modeling and analysis to evaluate 589 elective colectomy patients from 2007-2013 who follow similar progression of inpatient stay to identify their distinct trajectories of physiological measurements and likelihood of serious complications.

■ MD66

CC- Tahoma 5

Emerging Topics in Personalized Medicine II

Emerging Topic: Personalized Health

Emerging Topic Session

Chair: Dimitris Bertsimas, Massachusetts Institute of Technology, Cambridge, MA, 02139, United States

1 - Stable Regression: on the Power of Optimization over Randomization

Ivan Paskov, Massachusetts Institute of Technology, Cambridge, NY, United States, ipaskov@mit.edu, Dimitris Bertsimas

In this paper, we investigate and ultimately suggest remediation to the widely held belief that the best way to train regression models is via random assignment of our data to training/validation sets. In particular, we show that taking a robust optimization approach, and optimally picking such training/validation sets, leads to models that yield lower prediction error, prediction standard deviation, coefficient standard deviation, superior support recovery, and is also equivalent to constructing models that are robust to all subpopulations in the data. All of this is accompanied by a very efficient algorithm that scales this optimization approach to training to essentially any desired size.

2 - Optimal Forests

Yuchen Wang, Massachusetts Institute of Technology, Cambridge, MA, United States, yuchenw@mit.edu, Dimitris Bertsimas

In our previous work, we present Optimal Classification and Regression Trees, a novel approach to solve the decision tree problem using mixed-integer optimization and local search techniques that yields a near-optimal decision tree for axis-paralleled splits (OCT, ORT) and with hyperplane splits and a linear regression function in the leaf nodes (ORT-LH). In this work, we show how to use ORT to form Optimal Forests, which has better performance than from Forests using randomness. We use an example in healthcare to illustrate that.

3 - A Unified Approach to Mixed-integer Optimization: Nonlinear Formulations and Scalable Algorithms

Ryan Cory-Wright, MIT, Cambridge, MA, United States, Dimitris Bertsimas, Jean A.N. Pauphilet

We propose a unified framework to address a family of mixed-integer optimization problems, including network design, sparse portfolio and sparse learning problems. These problems exhibit logical relationships which are usually reformulated linearly using a big-M formulation. In this work, we challenge this practice by expressing the logical constraints in a non-linear way. By imposing a regularization condition, we derive a convex binary reformulation, which is solvable via an outer-approximation procedure. Our approach solves network design problems with 100s of nodes; sparse portfolio problems with up to 3,200 securities; and sparse regression problems with 100,000s of covariates.

4 - Fast Exact Matrix Completion: A Unifying Optimization Framework

Michael Lingzhi Li, Massachusetts Institute of Technology, Cambridge, MA, United States, mlli@mit.edu

We consider the problem of matrix completion. We show that both the general case and the case with side information can be formulated as a combinatorical problem of selecting k vectors from p columns. We demonstrate that it is equivalent to a separable optimization problem that is amenable to stochastic gradient descent. We design fastImpute based on projected stochastic gradient descent to scale beyond n=105 . We report experiments to show fastImpute is competitive in both accuracy and time needed across all cases. Furthermore, when a high number of entries are missing, fastImpute is over 70% lower in MAPE and 10x faster than current state-of-the-art methods.

5 - Novel Mixed Integer Optimization Sparse Regression Approach in Spectroscopy

Driss Lahlou Kitane, Massachusetts Institute of Technology, Cambridge, MA, United States, driss@mit.edu, Dimitris Bertsimas

Laser Induced Breakdown Spectroscopy plays an increasingly role in chemometrics as a tool for real time chemical analysis. After irradiating the surface of a material to be analyzed, spectra are collected and used to determine the chemical composition of the material with high precision. While standards methods to analyse the spectra rely on Partial Least Square and LASSO methods, we present a novel method using Mixed Integer Optimization methods for sparse regression to interpret and estimate chemical composition using collected spectra. Presented method significantly improves accuracy and interpretability.

■ MD67

S- Virginia

Simulation Analysis and Methods

Sponsored: Simulation

Sponsored Session

Chair: Qiong Zhang, Clemson University, Clemson, SC, 29634, United States

Co-Chair: Wei Xie, Northeastern University, Boston, MA, 02115, United States

1 - A Simulation-based Decision Framework for Stable, Flexible and Efficient Biomanufacturing Development

Wei Xie, Northeastern University, Boston, MA, United States, w.xie@northeastern.edu, Bo Wang, Tugce Martagan, Alp Akcay, Canan Corlu

We develop a stochastic simulation model for biomanufacturing risk analysis. By exploring bio-technology domain knowledge, we model how the properties or attributes of each batch dynamically evolves along the production process. We consider main sources of uncertainty leading to batch-to-batch variation. The proposed simulation framework can facilitate biomanufacturing risk management and guide operational decision making so that the stability of bio-drug quality can be improved while efficiently utilizing the resources and speeding up the time to market.

2 - Balancing Optimal Large Deviations in Sequential Selection

Ye Chen, Virginia Commonwealth University, Richmond, VA, United States, Ilya O. Ryzhov

In the ranking and selection problem, a sampling budget is allocated among a finite number of designs with the goal of efficiently identifying the best. A popular methodological strategy in the simulation literature is to first characterize optimal static allocations, by using large deviations theory to derive a set of optimality conditions, and then to use these conditions to guide the design of adaptive allocations. We propose a new methodology that can be guaranteed to adaptively learn the solution to these optimality conditions in a computationally efficient manner, without any tunable parameters, and under general assumptions on the sampling distribution.

3 - Dynamic Sampling Procedure for Selecting Important Nodes in Decomposable Random Network

Haidong Li, Peking University, Beijing, China, haidong.li@pku.edu.cn

In the world wide web and social networks, nodes are linked with each other randomly with certain transition probabilities, and their importance is ranked by the corresponding stationary probabilities in a Markov chain. We consider a Markov chain with several ergodic classes and unknown transition probabilities which can be estimated by sampling. In this study, we aim to select all of the best nodes in each ergodic class. Under a Bayesian framework, a dynamic sampling procedure is proposed to decompose the Markov chain and maximize a weighted probability of correct selection of the best nodes in each ergodic class. Numerical results demonstrate the superiority of the proposed sampling procedure.

■ MD68

S- University

Optimization in the Sharing Economy

Emerging Topic: Sharing Economy & Crowdsourcing

Emerging Topic Session

Chair: Konstantina Mellou, Massachusetts Institute of Technology, Cambridge, MA, 02141, United States

1 - Escrow Payments: A Smoother Driver Pay Mechanism

Daniel Freund, Lyft/MIT, 109 Lake St, Cambridge, MA, 14850, United States, df365@cornell.edu, Arash Asadpour, Garrett J. van Ryzin

Dynamic pricing is a frequently used tool to match supply and demand in the gig economy. The comparatively fast-paced dynamics of supply and demand have also led to dynamic pricing featuring prominently in the recent operations research literature.In practice, ridesharing platforms like Lyft and Uber no longer employ the strictly proportional commission. Further, beyond the driver's expected pay, the volatility in prices affects drivers' decision-making. We discuss a mechanism to smooth the driver's dynamic pay and analyze its properties in a stylized stochastic setting. We demonstrate both numerically and analytically the characteristics of the mechanism and discuss its potential benefits.

2 - Optimization in the Age of Connected and Automated Vehicles

Cathy Wu, Microsoft Research, Redmond, WA, United States

This talk describes techniques in machine learning and optimization critical for enabling mixed-autonomy mobility, the gradual and complex integration of automated vehicles into the existing transportation system. To address computational limitations of existing methods to large-scale control systems, generic reinforcement learning techniques for improved variance reduction are developed. Leveraging and advancing techniques in model-free deep reinforcement learning and control theory, the talk explores and quantifies the potential impact of a small fraction of automated vehicles on low-level traffic flow dynamics such as congestion on a variety of important traffic contexts.

3 - Dynamic Pricing and Matching in Ride-hailing Platforms

Chiwei Yan, Uber Technologies, San Francisco, CA, 94103, United States, University of Washington, Seattle, WA, United States, Nikita Korolko, Dawn Woodard, Helin Zhu

Advanced matching and dynamic pricing algorithms are the two key levers in ride-hailing platforms. We give a brief overview of state-of-the-art matching and pricing algorithms run by these platforms. We then demonstrate via a stylized model, calibrated with Uber data, that the synergy of these two levers can bring significantly more benefits. To be specific, we study a novel matching mechanism called dynamic waiting. We show that pricing and waiting could be jointly optimized in reducing rider and driving waiting times, lowering price volatility, and increasing trip volume and welfare.

4 - Car-sharing Service Design: A Simulation-based Optimization Approach for High Dimensional Problems

Tianli Zhou, Massachusetts Institute of Technology, Cambridge, MA, 02139, United States, Carolina Osorio

We present an algorithm for a class of high-dimensional discrete simulation-based optimization problems that arise in car-sharing service design. Through a Boston case study, we show how the use of analytical MIP information enables traditional simulation-based optimization algorithms to become scalable (i.e., suitable for high-dimensional problems) and computationally efficient. Specifically, we show how this MIP information improves the small sample size performance of both locally convergent and globally convergent general-purpose simulation-based optimization algorithms.

■ MD69

S- Seneca

SpORts Analytics IV

Sponsored: SpORts

Sponsored Session

Chair: Thomas Robbins, East Carolina University, Greenville, NC, 27858, United States

1 - A Competitive Analysis of Large Marathons

Thomas Robbins, East Carolina University, Greenville, NC, 27858, United States, robbinst@ecu.edu

A marathon is a 26.2 mile race. Every year tens of thousands of runners compete in marathons all over the world. The largest marathons attract more than tens of thousands of runners, with the largest marathon having more than 50,000 finishers. In this talk we review an analysis of more than 2.6 million times from 10 large marathons held over the last 10 years. We examine issues of competitiveness across races, age groups, and genders. We investigate how finish times as well as the effort to finish ahead of round number goals.

2 - The Impact of Rim Protectors in the NBA

Baback Vaziri, James Madison University, Harrisonburg, VA, 22807, United States, vaziribx@jmu.edu, Ryan Dailey, Scott Stevens

There are many factors that determine the makeup of an NBA roster. Thus, franchises are constantly evaluating these factors to help build a winning team. In this research study, the authors explore the impact of rim protectors on teams' regular season win total and championship outcomes from previous seasons. Traditional and binary logistic regression techniques are used to measure the statistical significance of the defensive rating (measure of defensive efficiency) of the rim protectors and their respective teams' projected 82 game win total and championship outcomes.

3 - Swing Shift: Placing Fielders to Minimize the Impact of a Batter

Kevin Hutson, Furman University, Dept of Mathematics, Greenville, SC, 29613, United States, kevin.hutson@furman.edu, Elizabeth Bouzarth, Andrew Hartley, Ella Morton, John Harris, Ben Grannan

Baseball is a sport that is tied to tradition. One of these traditions is the placement of fielders in the infield and outfield. Recently, some Major League Baseball teams have discarded tradition and moved fielders into seemingly strange configurations to try to increase the chances of getting a batter out or reduce the impact the batter has on the game. The rules of baseball only confine the positions of the pitcher and catcher, meaning that the other seven fielders are free to play anywhere. In this project we develop a MILP model that seeks the optimal field placement for each of the seven fielders so as to maximize a team's chance of getting a batter out based on the batter's specific hitting tendencies.

4 - Moneyball on Campus – As Experiential Learning

Scott Nestler, Academic Director, MSBA Program, University of Notre Dame, Notre Dame, IN, 46530, United States

In this presentation, we provide an overview of the process we followed to start a sports analytics club at the University of Notre Dame, beginning in 2016. Quick wins, showing value, buy-in from the athletics department, and organized student leaders are key. Specific examples from football, baseball, hockey, soccer, basketball, and volleyball will be shown. Additionally, we survey the landscape of what faculty and students are doing at other schools.

5 - Identifying Factors for Elbow Injuries of Major League Baseball Pitchers

Courtney J. Burris, University at Buffalo, Buffalo, NY, 14216, United States, cburris2@buffalo.edu, Demetrios Papazaharias, Carter Mann

Over the past decade, there has been an increase in analytics and data integration in sports. Accurate injury prediction for pitchers in MLB can have a significant economic effect throughout the league. We consider the problem of predicting which MLB pitchers are most at risk of tearing their UCL from a data science perspective. Also, we wish to understand which factors contribute most to a pitcher's injury risk. Factors are divided into three groups: cumulative metrics, performance metrics, and bio-metrics. Predictors from each of the three groups were considered when creating our models. We found that percentage of pitch types were the most important factors in predicting injury in MLB pitchers.

■ MD70

S- Jefferson A

Economic & Computational Issues in Digital Technologies

Sponsored: EBusiness

Sponsored Session

Chair: Abhishek Ray, George Mason University, Fairfax, VA, 47907, United States

1 - How to Hire Secretaries with Stochastic Departures

Shai Vardi, Purdue University, West Lafayette, IN, 47906, United States, Thomas Kesselheim, Alexandros Psomas

We study a generalization of the secretary problem, where decisions do not have to be made immediately upon candidates' arrivals.After arriving, each candidate stays in the system for some (random) amount of time and then leaves, whereupon the algorithm has to decide irrevocably whether to select this candidate or not. The goal is to maximize the probability of selecting the best candidate overall. We assume that the arrival waiting times are drawn from known distributions. Our first main result is a characterization of the optimal policy for this setting. We show that when deciding whether to select a candidate it suffices to know only the time and the number of candidates that have arrived so far. Furthermore, the policy is monotone non-decreasing in the number of candidates seen so far, and, under certain natural conditions, monotone non-increasing in the time.Our second main result is proving that when the number of candidates is large, a single threshold policy is almost optimal.

2 - How Platform Businesses Create Value by Lubricating the Frictions in the Markets? An Information Theoretic Perspective

Anparasan Mahalingam, Krannert School of Management and School of Industrial Engineering, Purdue University, West Lafayette, IN, 47906, United States, anparasan@purdue.edu, Richard J. Makadok

Our contention in this paper is that platform-based business models supported by digital technologies are able to succeed and create value by lubricating long-standing frictions in the markets. Theoretical model in this paper looks into three classic information-economics frictions; search costs, coordination costs, and transaction costs, and discuss how synergies among the capabilities for solving these three problems can help platform businesses build and sustain competitive advantage over either rival platforms or non-platform substitutes.

3 - A Meta-analysis of P-hacking in E-commerce Experiments

Alex Miller, PhD Student, Wharton School, University of Pennsylvania, Wharton School, Philadelphia, PA, 19104, United States

We study the prevalence of p-hacking in a sample of nearly 2,500 experiments from more than 250 e-commerce firms conducted on a large A/B testing platform. Contrary to expectations, our empirical results across several specifications provide little evidence for p-hacking in our sample. We develop a set of simulated counterfactuals to demonstrate that, if a modest effect of p-hacking did exist, our statistical methodology would have the power to detect it at our current sample size. Despite finding a null result, this research makes a valuable contribution by providing empirical evidence that informs our understanding of how firms may use/abuse modern testing platforms.

4 - Firm-specific Network Formation on Lightning Networks

Vipul Aggarwal, University of Washington, Seattle, WA, 98105, United States, aggarv@uw.edu, Wanyi Chen, Yong Tan

In this paper, we investigate the network formation mechanism for Lightning Networks (LN). LN are widely believed to be the solution to Bitcoin's (and other similar cryptocurrencies) scalability problem. LN allows transacting parties to create bidirectional payment channels between themselves through which funds can be transferred immediately at very, very low transaction fees. However, capital constraints restrict the addition of new nodes. We look into the firm-centric transaction needs of users and analyze their impact on the resulting network topologies.

■ MD71

S- Jefferson B

Procurement and Social Responsibility in Behavioral Operations

Sponsored: Behavioral Operations Management

Sponsored Session

Chair: Anyan Qi, The University of Texas at Dallas, Richardson, TX, 75080, United States

1 - The Behavioral Peril of Low Cost Sourcing

Jiayu Chen, The University of Texas at Dallas, Richardson, TX, 75080, United States, Anyan Qi, Elena Katok

We consider a stylized dyadic supply chain with one buyer and one supplier. The buyer decides the sourcing cost to pay the supplier, and the supplier decides the total surplus of the supply chain. We explore the behavioral peril of low-cost sourcing in such a supply chain and offer some novel and useful insights.

2 - Reliably Responsible: Structuring Supply Chains for Socially Responsible Behavior

Mahdi Mahmoudzadeh, Georgia Institute of Technology, Atlanta, GA, United States, Enno Siemsen

We revisit a classic model of responsible sourcing in supply chains by investigating behavioral influences on firms' decision to source from responsible and nonresponsible suppliers. The classic model predicts that only discouraging consumer reactions reliably incentivize firms to source responsibly. Our behavioral model predicts that an encouraging reaction, irrespective of its magnitude, always increases firms' responsible sourcing when the discouraging reaction from the market is weak, and further refines that a discouraging reaction always increases responsible sourcing irrespective of the type of product considered. We use a behavioral experiment to validate our behavioral model.

3 - Relational Strategies and Diversification in Nonprofit Organizations

Gloria Urrea, University of Colorado-Boulder, Boulder, CO, 47408, United States, gloria.urrea@colorado.edu, Sebastian Villa, Eric Quintane

Humanitarian organizations (HOs) face a tension to diversify operations. Diversification enables HOs to serve more social needs while increasing their chances to survive. However, diversification also reduces HOs' efficiency, which donors assess when deciding to provide funds. Literature typically assumes that HOs follow a broad relational strategy of approaching multiple donors to access funding. We argue that a broad relational strategy is inefficient and propose a second, more efficient, strategy: a focused relational strategy of developing long-term relationships with key donors. We empirically demonstrate the role of the focused relational strategy in fostering diversification.

4 - Shared Supplier Capacity as a Barrier to Socially Responsible Sourcing

Jacob Chestnut, Cornell College of Business, Ann Arbor, MI, 48108, United States, Ravi Anupindi

This experimental project considers the role of buyer behavior (e.g., time pressure, low margin, near delivery specificationchanges) in their supplier's performance along the dimension of social sustainability (forced OT, child labor, unauthorizedoutsourcing, etc.). We attempt to understand the relevant features (contractual and non-contractual) that suppliers use whencreating a preference ranking over buyers. Doing so allows us to assess the effectiveness of the operational and non-operationallevers that a "good buyer" might employ to improve their rank, thereby decreasing the likelihood that deviations occur on theirorder.

■ MD72

S- Columbia

Analytical Modeling in Information Systems

Sponsored: Information Systems

Sponsored Session

Chair: Samayita Guha, Temple University, Philadelphia, PA, 19121, United States

1 - When Worse is Better – Strategic Choice of Vendors with Differentiated Capabilities in a Complex Collaborative Environment

Shubham Gupta, Temple University, Philadelphia, PA, United States, tuj74944@temple.edu, Abhishek Roy, Subodha Kumar, Ram Mudambi

Existing literature on value co-creation has primarily focused on one (client) to one (vendor) relationship. We study the trade-offs and contract terms, in a complex yet practical value co-creation environment, featuring more than one vendor. We develop insights about the conditions under which the client prefers the more complex environment. We aim to find out scenarios under which a client would be better off working with two vendors instead of one. We show that the client could be better off adding a less efficient vendor. We also show the impact of adding new vendor on existing vendor.

2 - How to Make My Bug Bounty Cost-effective: A Game-theoretic Analysis

Leting Zhang, Temple Universisty, Philadelphia, PA, 19122, United States, Subodha Kumar

As a crowd-based cybersecurity solution, bug bounty programs have drawn extensive attention in recent years. By leveraging the wisdom of a group of security researchers, a firm could identify vulnerabilities in software systems earlier and patch them to prevent the potential losses caused by cyber incidents. However, because of information asymmetry and coordinated problem, a firm faces tradeoffs in deciding bounty and patching time in bug bounty programs. This paper uses a game-theoretical model to illustrate interactions between a firm and security researchers in a bug bounty program, then examining firms' decisions from the perspective of cost-effectiveness.

3 - Tackling Android Fragmentation: Strategies of Android Platform and Mobile Apps

Xi Wu, Fox School of Business, Temple University, Philadelphia, PA, United States, xi.wu@temple.edu, Subodha Kumar

Android has been criticized for its "Fragmentation Problem" in the past decade. How to address this issue becomes critical and imperative for the platform. In this work, we examine the Android's enforcement strategy on stimulating mobile apps updating their Android version and how mobile apps decide on the targeted Android version. We find some interesting results that mobile apps with low user base and high functionality size are unlikely to update. We also find that the optimal version requirement is not monotonic to the benefit and the developing cost that updating to a new Android version brings to the mobile apps. Our results provide practical insights to the mobile app developers and the platform.

4 - Dynamics of Competition in On-demand Economy: A Differential Games Approach

Samayita Guha, Temple University, Philadelphia, PA, 19121, United States, samayita.guha@temple.edu, Emre M. Demirezen, Subodha Kumar

The viability and success of ride-hailing platforms depend on how they manage their demand and pool of available drivers. In this paper, we examine how ride-hailing platforms can meet demand with supply in a competitive setting where the number of available drivers depends on policies of the platforms; and demand depends on current prices across multiple platforms for the current ride, perceptions of the platforms among their customers, and the expected wait times in different platforms. We develop our model in a differential game setup and consider a scenario of duopoly with two platforms. We discuss several managerial insights from our model and elaborate on the existing business practices.

■ MD73

S- Boren

Grab Bag: AI, Stockouts, and More

Emerging Topic: INFORMS Section on Practice

Emerging Topic Session

1 - Using AI to Co-develop New Product Formulations

Robin Lougee, IBM Research, IBM TJ Watson Research Center, Yorktown Heights, NY, 10598, United States, Jing Fu, Richard Goodson, Christian Harris, Kimberly Lang, Joana Maria, Richard Segal, Tenzin Yeshi

Each year, more than 30,000 new consumer products are launched. An estimated 80% fail. In this presentation, we introduce computational creativity, present challenges in new product creation and share results from a novel AI system that helps product developers more efficiently and effectively create new product experiences.

2 - Democratization of Data Science to Combat AI and Machine Learning Bias

Brian Wright, Co-Director, Data Science Graduate Programs GW, George Washington University, Washington, DC, United States, bwright.wright6@gmail.com

The expansion of AI into commonplace everyday life brings with it the unanticipated challenge of confronting algorithmic decisions or recommendations that could be considered bias or even unethical. Technical approaches to combat bias have been advancing in recent years and show great promise, however, these solutions can only partly address the problem. Research shows that increases in general knowledge related to AI systems actually reduces trust. I'll discuss how this distrust could be healthy, that the nature of the field of data science works in our favor and ways that we can facilitate broader awareness to elicit increased discourse and allow for a "healthy distrust" of AI.

3 - Using AI/ML to Deliver a Smarter Supply Chain

Duncan Klett, Kinaxis, Ottawa, ON, Canada

A good demand forecast is better than no forecast at all, and AI/ML methods can certainly provide a better forecast, but, it's what you do with that forecast that counts. In this session, learn how to apply AI/ML models for:* Strategy and segmentation,* Managing change, and* Mitigating risks.To Each of these areas enable organizations to respond to supply chain variability more effectively to achieve business success.

4 - Analytics and OR for IBM's IT Service Deals

Aly Megahed, IBM Research-Almaden, 150 Palm Valley Blvd Apt 2066, San Jose, CA, 95123, United States

IBM Services competes to win highly-valued IT service contracts. To help IBM Services be more competitive and win more deals, the IBM Research team invented tools that leverage novel analytics and OR methods. The tools have been implemented and deployed in production, and have resulted in significant win rate increases, and a realized revenue increase of almost $350M.

■ MD74

S- Capitol Hill

Survival Guide for Junior Faculty

Sponsored: Junior Faculty JFIG

Sponsored Session

Chair: Ehsan Salari, Wichita State University, Wichita, KS, 67260, United States

Co-Chair: Canan Gunes, Carnegie Mellon University, Pittsburgh, PA, 15213, United States

Survival Guide for Junior Faculty

Canan Gunes Corlu, Boston University, Boston, MA, 15213, United States, canan@bu.edu

Panelists from both business and engineering schools will share tips about surviving the first years of your career.

Panelists

- Maria Esther Mayorga, North Carolina State University, Dept. of Industrial & Systems Engineering, Raleigh, NC, 27695, United States, memayorg@ncsu.edu
- Dursun Delen, Oklahoma State University, Tulsa, OK, 74106, United States
- Douglas Morrice, University of Texas-Austin, Irom Department, Austin, TX, 78712-1750, United States
- Sandra D. Eksioglu, Clemson University, Department of Industrial Engineering, Clemson, SC, 29634, United States

■ MD77

S- Fremont

Project Management

Contributed Session

Chair: Anshuman Tripathy, Indian Institute of Management-Bangalore, Bannerghatta Main Road, Bilekahalli, Bangalore, 560076, India

1 - An Improved Alternative to Heat Map Risk Matrices for Project Risk Prioritization

Jamie Monat, Professor of Practice, Worcester Polytechnic Institute, Worcester, MA, United States, jmonat@wpi.edu, Scott Doremus

Heat map risk matrices are widely used to prioritize project risks, but they suffer from several weaknesses, notably subjectivity, symmetry, category prioritization reversal, and a failure to account for Risk Aversion. Because of this, they can lead to serious mis-prioritization and mismanagement of risks. We propose an alternative project risk prioritization technique: the Risk-Adjusted Loss (RAL) method, and experimentally demonstrate its superiority over the heat map risk matrix approach.

2 - Resource-constrained Project Scheduling Problem in a Real-world Heavy Industry Company

Yoojin Na, Pohang University of Science and Technology (POSTECH), Pohang, Kyungbuk, Korea, Republic of, yoojin317@postech.ac.kr, Byung-In Kim, Minseok Song, JongWon Kim

This study presents a resource-constrained project scheduling problem. Multiple projects are considered and each project has about 7000 activities and 8000 activity-activity relations. There are four relation types, FS (finish to start), SF, SS, and FF, and each relation has an offset delay time. The offset can be negative. Every activity requires a specific type of resource and multiple resource types are considered. The objective of the problem is to minimize the total duration of all the projects. We propose a mixed integer programming formulation and an efficient algorithm for the problem.

3 - Lessons Learned in Building a Resilient and Adaptive Enterprise Project Management Office at U. S. Energy Information Administration

Tuncay Ugur Alparslan, U.S. Department of Energy, Washington, DC, United States, Tuncay.Alparslan@eia.gov

In 2016 the Energy Information Administration (EIA), a statistical agency within the Department of Energy, created an enterprise Project Management Office (PMO) to help improve its performance delivering on cross-cutting new products. The PMO developed measures and its own maturity model, based on a study of industry best practices, to help it stay focused on developing governance standards, tools and templates, a training program, a portfolio management approach, and quality stakeholder engagement. The presentation will cover lessons learned in piloting, sequencing, and maturing activities to build a resilient and adaptive PMO.

4 - Capabilities Erosion: An Architecture-viewed Approach to the Commons Challenge

Anshuman Tripathy, Indian Institute of Management-Bangalore, Bangalore, India, Shikha Safaya

The trend of successive offshoring by the US firms for arbitrage benefits has led to long-term erosion of manufacturing capabilities crucial to rebuilding its economy. We adopt a system architecture perspective to observe the capability loss for an OEM outsourcing manufacturing, and subsequently design to a CM. Studying the impact of modularity on system architecture, we find that higher modularity encourages offshoring and leads to a rapid decline in manufacturing knowledge of the OEM but a counter-intuitive increase in its system knowledge.

■ MD78

S- Greenwood

Estimation issues in Frontier Estimation

Emerging Topic: Productivity, Efficiency and Data Envelopment Analysis

Emerging Topic Session

Chair: John Ruggiero, University of Dayton, Dayton, OH, 45469-2251, United States

1 - Vine-copulas for Stochastic Frontier Analysis

Artem Prokhorov, University of Sydney, 6 Tantangara Place, Sydney, 2767, Australia, artem.b.prokhorov@gmail.com

The talk is about how to use copulas to measure firm efficiency and productivity. Copulas are mathematical concepts that model dependence between random variables. Traditional stochastic frontier analysis has ignored important aspects of production where dependence plays a key role. The dependence influences simultaneous decisions on how much to produce and what proportions of inputs to use. It influences how factors outside our control such as extreme weather or new legislation, affect how inefficient we are. Appropriate copulas capturing these dependencies allow for robust estimation and testing of production models and achieve remarkable improvements in productivity and efficiency.

2 - Examining the Determinants of Cost Efficiency of Primary Health Care Organizations: Latent Class Stochastic Frontier Analysis

Kwadwo Arhin, Lecturer, Ghana Institute of Management and Public Administration, Accra, Ghana, arhinkwadwo@gmail.com, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana, arhinkwadwo@gmail.com, Eric Oteng-Abayie

The study was conducted using a panel data stochastic cost frontier with latent classes which allows the data to construct different frontiers for each group and evaluation of cost efficiency levels is carried out with respect to each group's own frontier. The Cobb-Douglas cost function model was employed. The latent class membership analysis is based on the hypothesis that unobservable technological heterogeneity exists among PHC facilities. The study results reveal that there are three statistically significant classes in the sample and that the effects of the major determinants of cost efficiency of a PHC facility are influenced by the class structure of that facility.

3 - Implicit Estimation for Stochastic Frontier Model

Mohamed Nejib Ouertani

The paper propose a novel approach (the Implicit approach), competitor to the Bayesian one, to estimate stochastic frontier models. As we reckon, to our limited knowledge, this approach steel has not been applied to the stochastic frontier approach. Hence, for the aim of highlighting the usefulness of this method we intend to establish a comparative analysis with the Bayesian one. For this purpose, the Markov Chain Monte Carlo (MCMC) techniques are used and implemented for both approaches subject of our study. Results shows that the Implicit approach is more appropriate than the Bayesian one, mainly with the presence of an improper prior case as well as a non-informative prior one. As matter of fact, our new approach has been applied in the case of a sample of Tunisian insurers.

4 - Measuring Efficiency Gains Using Distance Functions with Optimal Directions: Evidence from the U.S. Hospital Sector

Michael Vardanyan, Associate Professor, IESEG School of Management, Paris, 78100, France, Gary Ferrier, Herve Leleu, Vivian G. Valdmanis

Efficiency and productivity studies using directional distance functions have traditionally relied on ad hoc directions for projecting inefficient observations on the frontier of technology. Several recent studies have demonstrated how to select directions optimally, eliminating the need for placing restrictive assumptions on the components of the corresponding vector. We rely on Färe et al. (2017), who show how the goal programming algorithm of Aigner and Chu (1968) can be extended to endogenize the direction vector using nonlinear programming. We use the U.S. health sector data from 2004 to 2016 to estimate the output shortfalls and excess input use among various categories of hospitals.

5 - Estimating Efficiency with Quantile Functions

John Ruggiero, University of Dayton, Dayton, OH, 45469-2251, United States, jruggiero1@udayton.edu, Samah Jradi

In this paper we consider the estimation of efficiency of individual decision making units using quantile function estimation. Given the underlying distribution of measurement error and noise, we propose a quantile based measure of efficiency. We illustrate our approach using simulated and real world data and compare the results to alternative approaches.

■ MD79

S- Issaquah A

Joint Session Agriculture/Practice Curated: Breaking Through: How Can We Deliver the Global Food Supply By Accelerating Innovation in Data Analytics?

Emerging Topic: Agriculture

Emerging Topic Session

Chair: Greg Doonan, Syngenta, Slater, IA, 50244, United States

Moderator

Greg Doonan, Syngenta, 2369 330 Street, Slater, IA, 50244, United States

The audience will have the opportunity to hear firsthand how data & digital analytics and operations research are driving innovation within agriculture. The panel features experts from industry, research centers and foundations that are focused on improving agricultural production across the globe. Listen to the exciting and innovative work that is being performed, the challenges they are addressing and the opportunities that remain to address global food security for an ever growing population.

Panelists

- Brian King, CIAT, Kilometro Palmira, 763537, Colombia
- Stewart Collis, Gates Foundation, Seattle, WA, United States
- Anirudh Badam, FarmBeats, Redmond, WA, United States
- Zaynab Saad, Syngenta, Dearborn Heights, MI, United States

■ MD80

S- Issaquah B

TIMES Distinguished Speaker

Sponsored: Technology, Innovation Management & Entrepreneurship

Sponsored Session

Chair: Gulru F. Ozkan-Seely, University of Washington Bothell, Bothell, WA, 98011, United States

1 - Innovating Innovation and Product Operations Research

Vish Krishnan, University of California, La Jolla, CA, United States

Turbulent times demand creative solutions. Research in innovation and new product operations can offer much to broaden the scope and enhance the impact of technology and operations management areas. In this talk, we discuss concrete research opportunities that help achieve policy and social impact as well as speak to the worlds of startups and high-growth enterprises.

■ MD81

S- Kirkland

Strategic Energy Systems Planning Models

Sponsored: Energy, Natural Res & the Environment/Natural Resources Petrochemicals

Sponsored Session

Chair: Dimitri Papageorgiou, ExxonMobil Research & Engineering, Annandale, NJ, 08886, United States

1 - Strategic Decision-making on Mature Offshore Oil and Gas Fields

Steffen Bakker, Norwegian University of Science and Technology, Trondheim, Norway, Asgeir Tomasgard

An increasing number of offshore oil and gas fields is reaching the end of their productive life-times. On these fields the main infrastructure is in place and the main decisions are typically when to shut down which wells. Nonetheless, strategic decisions can be made to enhance production and to increase the net present value of the asset. These decisions might include tying in new wells, performing slot recoveries or drilling injection wells to enhance oil recovery. In this work we present a first version of a multistage stochastic integer programming model that maximizes the net present value of an existing field and judge its performance for different instance sizes.

2 - Projecting North American Natural Gas Markets: The Natural Gas Market Module in The National Energy Modeling System

Michael Cole, U.S. Energy Information Administration, Washington DC, DC, United States, Kathryn Dyl, Yelena Dandurova, Peter Gross, Samantha Calkins

The National Energy Modeling System (NEMS) provides 25-30 year projections of a broad range of energy issues at both U.S. national and regional levels for the U.S. Energy Information Administration. The Natural Gas Market Module (NGMM) component of NEMS projects natural gas supply, end-use prices, and flow patterns of natural gas throughout the North American pipeline network. The NGMM employs a quadratic optimization model that solves for market equilibrium across the three main components of the natural gas market: the supply component, the demand component, and the transmission and distribution network that links them.

3 - Scenarios for Decarbonization of the Future Indian Electricity Sector

Dimitri Papageorgiou, ExxonMobil Research & Engineering, Annandale, NJ, 08886, United States, Ivan Rudnick, Audun Botterud, Carlos Batlle Lopez, Pablo Duenas Martinez, Bryan Mignone, Srinivasan Rajagopalan, Michael Harper, Karthik Ganesan

Using a high temporal resolution power system capacity expansion model, we investigate the impact of technology and policy assumptions on generation and energy storage capacity through a scenario-based study of India's 2037 grid. Results suggest that significant CO2 emissions reductions could be realized by developing viable decarbonization approaches and VRE growth may be constrained unless it is viably paired with natural gas and/or storage to enable reliable power generation.

4 - Simulation for Strategic and Operational Petrochemical and Logistics Planning

Mamdouh Mubarak, ExxonMobil Research & Engineering, Annandale, NJ, United States

We present examples of how simulation can be used to enhance decision support for strategic and operational petrochemical and logistics problems.

■ MD82

S- Leschi

Issues in Energy Supply Chain

Sponsored: Energy, Natural Res & the Environment/Environment & Sustainability

Sponsored Session

Chair: Jason Nguyen, University of New South Wales, Sydney, Australia

1 - Supporting Supplier Competitiveness in High Energy Price Environments: The Role of Industry Targeted Interventions

Jason Quang Nguyen, University of New South Wales, Carlson School of Management, 321 19th Avenue South, Sydney, 55455, Australia, j.nguyen@unsw.edu.au, Karen L. Donohue, Mili Mehrotra

Energy consumption cause negative externalities to society which are not internalized into energy prices without policy interventions. This creates a disincentive for investing in Energy Efficiency (EE) improvements. However, internalizing these externalities into energy prices may affect the competitiveness of small-and-medium-sized enterprises (SMEs), as they could not pass these costs to larger customers. Most extant research has not examined the effectiveness of industry targeted interventions to mitigate the pressure of increased energy prices. In this study, we address these issues, focusing on the two most common interventions, energy price discount and EE investment subsidy.

2 - Utility-owned Combined Heat and Power: Improving Reliability and Lessening Environmental Impact

Eric M. Webb, Assistant Professor, University of Cincinnati, Cincinnati, OH, 45226, United States, eric.webb@uc.edu, Gilvan Souza, Owen Wu

Combined heat and power (CHP) plants generate electricity and useful heat at the same time. There are many benefits to utilities of having CHP plants in their portfolio, including reducing transmission losses, increasing power reliability, and meeting environmental regulations. Despite these benefits, only 3% of all CHP capacity in the U.S. is utility owned. We study the economics of utility ownership of CHP plants and examine the effect of regulatory policies on such investments. To encourage installation, we find a low to moderate emission tax to be most effective.

3 - Strategic Bidding of Wind Farms in a Competitive Electricity Market

Ali Shantia, Assistant Professor, Toulouse Business School, Toulouse, France, a.shantia@tbs-education.fr, Roman Kapuscinski, Owen Wu

We empirically study how strategic behavior of renewable generators translates to their higher profitability. Using the day-ahead and real-time market data, provided by Midcontinent Independent System Operator (MISO), we study what differentiates the bidding behavior of wind farms and analyze whether such strategic behaviors practically increase wind generation profitability and how this effect is moderated by market competition and wind intermittency.

4 - How Should Electricity Suppliers Trade to Optimally Hedge the Risk Associated with Power Demand Uncertainty?

Julien Vaes, University of Oxford, Oxford, United Kingdom, Julien.Vaes@maths.ox.ac.uk

As of now, electricity cannot be stored in large amounts. Because at all times supply must match demand, suppliers take long positions beforehand on the power future market in order to ensure the best price for customers. Subjected to power price and demand uncertainty, a risk-averse supplier most likely seeks the cheapest trading strategy. However, solving the required optimisation problem is cumbersome, as risk is estimated with Monte-Carlo simulations. To circumvent this issue, we suggest an estimation of the CVaR-risk measure based on a PCA making the problem more tractable while yielding to competitive solutions.

5 - Optimisation of Decarbonisation Pathways for Heat and Power Sectors in the UK

Vasileios Charitopoulos, Research Associate, University of Cambridge, Cambridge, United Kingdom, v.charitopoulos@jbs.cam.ac.uk, Chi Kong Chyong, David Reiner

In the present work, a spatially explicit optimisation-based approach to investigate the trade-offs among the different decarbonisation pathways on a national scale is proposed. The model simultaneously optimises investment and operational decisions for the power and heat sectors. By considering the whole multi-energy system, economic and policy insights are drawn based on the trade-offs between: (i) the electrification of off-gas grid areas, (ii) the role of hydrogen in substituting the incumbent natural gas-based system. Finally, results showcase how acknowledging resource endowments at sub-national level enables for synergistic decarbonisation of heat and power sectors.

■ MD83

S- Medina

Improving Power System Resilience and Flexibility Through Advanced Computation

Sponsored: Energy, Natural Res & the Environment/Electricity

Sponsored Session

Chair: Shmuel S. Oren, University of California-Berkeley, Berkeley, CA, 94720-1777, United States

Co-Chair: Georgios Patsakis, University of California Berkeley, Berkeley, CA, 94702, United States

1 - Optimization Methods to Enhance Resiliency of Distribution Systems

Chen-Ching Liu, AEP Professor and Director of PEC, Virginia Tech, Blacksburg, VA, United States, ccliu@vt.edu, Juan C. Bedoya, Jing Xie, Yubo W., Xi Zhang

Recovery of distribution systems from extreme operating conditions is vital, especially when the utility system is not available. The increasing penetration of distributed energy resources (DERs) in power networks opens a path for restoration of critical load using local non-utility resources. To do so, it is required to leverage available resources such that critical loads can be restored quickly. This presentation will provide a summary of recently developed distribution system restoration approaches where a resiliency function is maximized.

2 - Mixed Integer Programming Techniques for Efficient Black Start of the Power System

Georgios Patsakis, University of California Berkeley, Berkeley, CA, 94702, United States, gpatsakis@berkeley.edu, Ignacio Aravena, Deepak Rajan, Shmuel S. Oren

The power system operator relies on a few units (black start units) to restore the system after a large-scale outage. The problem that optimally allocates these units in the grid and restores the power system after an extended outage can be posed as a large-scale mixed integer program over the allocation and switching actions for a finite time horizon. We explore techniques to increase the computational efficiency of the problem: we describe how by using a stronger formulation of part of the constraints, a decomposition of the problem, and customized heuristics, we can obtain restoration plans with optimality guarantees within reasonable computational times.

3 - Distributed Restoration for Integrated Transmission and Distribution Systems with Distributed Energy Resources

Wei Sun, University of Central Florida, Orlando, FL, United States, sun@ucf.edu

This talk will introduce a distributed strategy for integrated transmission and distribution systems restoration. Based on ADMM, the distributed algorithm is able to provide the coordinated restoration for both transmission and distribution system operators by sharing limited information of boundary buses in an iterative procedure. The strategy coordinates the operation of distributed energy resources in terms of serving high priority loads across different networks. The effectiveness and advantage of developed models and algorithms are validated through testing of the integrated IEEE test cases.

4 - Algorithms for Optimal Design and Operation of Resilient Microgrids

Harsha Nagarajan, Los Alamos National Laboratory, Los Alamos, NM, 87544, United States

Microgrids have received increasing interest from utilities to support the resiliency posture of their systems. Various factors prevent remote communities from connecting to transmission systems and they rely on off-grid microgrids. Hence, we present methods that facilitate design and operation of off-grid microgrids over long periods of time. This includes modeling of component efficiencies and limits, batteries, unit commitment, capacity expansion, and power flow physics. We propose efficient model-predictive-control-based algorithms and corroborate the methods with extensive numerical studies.

■ MD84

S- Ravenna A

Energy Modeling Platform for North America as Part of Worldwide Open Energy Modeling Efforts

Sponsored: Energy, Natural Res & the Environment/Energy Sponsored Session

Chair: Denis Lavigne, PhD, Royal Military College St-Jean, St-Jean-sur-Richelieu, QC, J2W 1E9, Canada

Co-Chair: Taco Niet, Simon Fraser University, BCIT, Burnaby, BC, V5G 3H2, Canada

1 - OSeMOSYS-PuLP

Mark Howells, KTH Division Energy Systems Analysis, Brinellvagen 68, Stockholm, 18368, Sweden, mark.howells@energy.kth.se

Recent open-data movements give access to large datasets derived from real-world observations. This data can be utilized to enhance energy systems modeling. Heterogeneity and randomness of the real-world can be captured that are usually found in large samples of real-world data. This paper presents a methodological framework for an empirical deterministic-stochastic modeling approach to utilize large real-world datasets in long-term energy systems modeling. A new software system—OSeMOSYS-PuLP—was developed and is available now.It adds the feature of Monte Carlo simulations to the existing open-source energy modeling system (the OSeMOSYS modeling framework).

2 - Impact of Prolonged Droughts on Colombia's Electric Infrastructure in a Low Carbon World: A Case Study using OSeMOSYS

Cristina Botero, Argonne National Laboratory, Lemont, IL, United States

Colombia's 50 million population relies on hydroelectric (dam) plants to satisfy 86% of its 70TWh yearly electricity demand. This makes the country's 16GW electric capacity extremely vulnerable to prolonged droughts, which are expected to become more frequent as a result of climate change. This study uses the open source tool OSeMOSYS to evaluate the impact of prolonged drought periods on Colombia's electricity mix in the next 30 years in a world with a high price on carbon. The influence of natural gas pricing is also considered, given Colombia's uncertain reserves and pricing forecasts.

3 - U.S. Electricity Infrastructure of the Future: Generation and Transmission Pathways Through 2050

Benjamin D. Leibowicz, Assistant Professor, University of Texas-Austin, Austin, TX, 78712-1591, United States, bleibowicz@utexas.edu, Gopika Jayadev, Erhan Kutanoglu

We develop an optimization model for the U.S. generation and transmission system and use it to explore electricity infrastructure pathways through 2050. By comparing results from numerous scenarios, we affirm five key insights and discuss their policy implications. For instance, we find that U.S. electricity can be substantially decarbonized at modest cost, but complete decarbonization is very costly. Investments in long-distance transmission are very limited, while investments in battery storage are much greater, under a wide range of assumptions. Optimal solutions include large investments in natural gas capacity, but gas capacity utilization rates decline steadily and significantly.

4 - The Regional Energy Deployment System (ReEDS): An Open-Access Model for the North American Electricity System

Kelly Eurek, National Renewable Energy Laboratory, Golden, CO, 80226, United States, Kelly.Eurek@nrel.gov, Maxwell Brown, Wesley Cole

The Regional Energy Deployment System (ReEDS) model is NREL's flagship capacity expansion planning tool for the electric power sector in North America. Originally developed in 2001, ReEDS has been used primarily by NREL researchers to conduct high-profile analysis of the potential evolution of the electricity system. In September 2019, the core model is being released for public use. In this presentation, we provide an overview of the model architecture, key model features, data sources, lessons learned, and sample model results for the North American electric power system.

5 - Building Better Models Through Collaboration

Taco Niet, Faculty, Simon Fraser University, Surrey, BC, V5G 3H2, Canada, taco_niet@sfu.ca

Many model analyses provide a path to low carbon energy but many of these studies use proprietary software and data, making their analysis opaque and impossible to validate. There is a significant movement in the modelling community towards open source and open data. In this presentation we will present a number of examples where collaboration and sharing of both source code and model data has resulted in errors being caught and better models being developed. The sharing of model source code and data makes for better models and better decision making.

■ MD85

S- Ravenna B

Complex Infrastructure Systems

Sponsored: Energy, Natural Res & the Environment/Energy Sponsored Session

Chair: Valerie Thomas, Georgia Tech, Atlanta, GA, 30332, United States

1 - Integrated Process Optimization for Biochemical Conversion

Sandra D. Eksioglu, Clemson University, Department of Industrial Engineering, Clemson, SC, 29634, United States, seksiog@clemson.edu, Berkay Gulcan, Mohammad Sadekuzzaman Roni, Krystel Castillo

The objective of this study is to develop analytical tools to enable a biorefinery to identify optimal integrated process design to ensure a reliable, cost-effective, sustainable, robust and continuous feeding of biomass feedstocks to achieve the design throughput of the reactor. We propose a two-stage stochastic optimization. The first stage decides about long and medium term commitments of equipment capacities and settings. The second stage decides the flow of the biomass between equipment and the inventory kept under random discharge and failure rates of each equipment. A Discrete Element model develops functional relationships between product characteristics and equipment performance.

2 - Structure of Electricity Production Planning Models

Valerie Thomas, Georgia Tech, ISYE, Atlanta, GA, 30332, United States, vthomas@isye.gatech.edu

Electricity production planning models are widely used for analysis of future electricity system development in both developing and developed countries. Analysis of a typical electricity production planning model for developing countries shows structure that provides insight into the conditions under which substantially different electricity systems would be constructed for a given objective.

3 - Presenter

Hyejin Youn, Kellogg School of Management, Evanston, IL, United States

Urban scaling and its relation to the universality and self-similarity seem both trivial and non-trivial. On one hand, the dynamics of cities are so complex that it seems impossible to explain them in a simple way. Geographic factors and idiosyncratic historical paths are so entangled and complex that even a well-designed plan often results in unintended consequences. This contradicts the universality observed in almost every urban phenomenon due to its implication that the underlying dynamics are reducible to a simple form. On the other hand, universality is a natural, and even trivial, consequence derived from a common set of functionalities of cities, which are manifested as a single scaling law.

4 - Designing a Coal and Biomass Based Electricity Network Considering Different Emission Schemes

Vinay Gonela, Texas A. & M. University Central Texas, Killeen, TX, United States, vinay.gonela@tamuct.edu, Iddrisu Awudu, James Gosnell

This research focuses on designing a coal and biomass based electricity network considering different emissions schemes such as carbon cap, carbon tax, and carbon cap and trade. A stochastic optimization model is proposed that aims to determine the optimal location, production, and raw material procurement strategies under different emission schemes. A case study of North Dakota is used to illustrate the effectiveness of the proposed stochastic optimization model. The results provide optimal electricity network under different emissions schemes and at the same time help determine the best emission scheme. Sensitivity analysis is also conducted to provide managerial insights.

■ MD86

S- Ravenna C

Trade-offs in Temporal, Geographic and Operational Granularity in Modeling Low-carbon Power Systems

Sponsored: Energy, Natural Res & the Environment/Energy

Sponsored Session

Chair: Michael Davidson, University of California, San Diego, CA Harvard Kennedy School, MA, United States

1 - Electricity Capacity Expansion Modeling with Distribution Networks and Distributed Energy Resources

Jesse D. Jenkins, Assistant Professor, Princeton University, Princeton, NJ, 02139, United States, Dharik Sanchan Mallapragada, Nestor Andres Sepulveda, Scott P. Burger

We present a new approach to model distributed energy resources (DERs), flexible and price-responsive demand, and distribution network losses and reinforcement costs alongside conventional generation and transmission network assets in an integrated electricity system planning framework. The methods capture important tradeoffs between locational value and economies of unit scale and help identify optimal deployment of DERs. We discuss results from a case study evaluating distributed solar photovoltaic and battery energy storage deployment to illustrate the value of the modeling framework.

2 - Scalable Integrated Infrastructure Planning with PowerSimulations.jl

Clayton Barrows, NREL, 15013 Denver West Parkway, Golden, CO, 80401, United States

We are witnessing a revolutionary transition of energy infrastructure around the world. Future infrastructure systems will be required to deliver critical services reliably, resiliently, securely, affordably, and in an environmentally responsible fashion. NREL is developing a suite of new scalable modeling and analysis capabilities to understand and inform this transition by enabling flexible representations of system planning and operational phenomena. This presentation will focus on the power system modeling capabilities enabled through PowerSystems.jl and PowerSimulations.jl.

3 - Value of Modelling Constraints in Generation Scheduling

Miguel Ortega-Vazquez, Sr. Technical Leader, Palo Alto, CA, 94304, United States

Power system tools based on unit commitment (UC) follow a top-down approach. These models concentrate on the top decision-making process and little detail is given to the UC process. As the penetrations of renewables deepen, the variability and uncertainty of the net-load increases requiring specific generation scheduling patterns. Also as energy storage is integrated, full temporal resolution becomes essential. These characteristics are ignored or indirectly accommodated in UC proxies and neither accuracy nor feasibility is guaranteed.The value of constraints is assessed for full temporal UC models to tradeoff among solution cost; solution reliability; and computational burden.

4 - Spatially Granular Renewable Resource Curves for Power System Planning

Michael R. Davidson, University of California, San Diego, La Jolla, CA, 02139, United States, mrdavidson@ucsd.edu, Da Zhang

Power system planning models of high renewable penetrations typically aggregate resource profiles over a large area—thus underestimating the variability of marginal capacity additions—or replicate a single resource profile—thus underestimating geographic smoothing. In this work, we derive spatially disaggregated supply curves for China's wind and solar resources based on a simplified power systems operation heuristic that maintains temporality and basic commitment constraints. The supply curves are further used to cluster contiguous areas of renewable resources as inputs to an expansion planning optimization.

■ MD92

S- Grand Ballroom A

Supply Chain, Closed Loop

Contributed Session

Chair: Kamil Ciftci, Lehigh University, Bethlehem, PA, 18015, United States

1 - Closed-loop Supply Chain Models with Buyback and Remanufacturing

Shuting Xu, Xiamen University, Xiamen, China, 17720150150164@stu.xmu.edu.cn, Zhaowei Miao

This paper develops two-period dynamic models to analyze the OEM's operation decisions while considering both buyback and remanufacturing strategies in its closed-loop supply chain. Two kinds of scenarios of buyback commitment are discussed in this paper, including with/without buyback commitment in Period 1 respectively. The results show that pre-announcing buyback rebate in Period 1 will promote OEM to adopt buyback and remanufacturing, and help OEM to attain more profit. This paper also provides some management insights for the policy maker.

2 - A Comparison of Collection Subsidy vs. Dismantling Subsidy: Government Policy in the New Energy Vehicle Battery Recycling Industry

Peiqi Ding, Northwestern Polytechnical University, Xi'an, China, dingpeiqi@mail.nwpu.edu.cn

As the number of waste batteries increases, firms involved in the new energy vehicle industry need to properly collect them, but what party is responsible remains unclear. Governments introduce two subsidies, i.e., collection subsidy and dismantling subsidy. We develop a stylized model to examine the collection strategies and compare the subsidies. We derive several insights from analysis. First, the collection strategies depend on the fixed collection cost. Second, the key factor determining the subsidy preference is the ratio of the dismantling cost to the raw material cost. Finally, governments decide the type of subsidies in terms of collection rate, environmental impact and social welfare.

3 - A Fuzzy Multi-objective Facility Location Model for Closed-loop Supply Chain Network Design under Uncertainties

Guiping Hu, Iowa State University, Ames, IA, 50011, United States, gphu@iastate.edu, Zhengyang Hu

The significance of considering both forward and backward flows in supply chain networks spurs an interest to develop closed-loop supply chain networks (CLSC). In this paper, a CLSC problem with two objective functions is investigated which includes minimizing overall cost and maximizing positive environmental impact. CLSC is one of the long-term decision making problems and hence a lot of parameters may have uncertain nature. A fuzzy programming model is proposed to cope with various uncertainties and an aggregation function is adopted to integrate different objective functions. A sensitivity analysis is provided to explore the impact of different input parameters.

4 - Two-period Closed-loop Supply Chain Model for Consumer Returns

Kamil Ciftci, California State University, Fresno, CA, United States, Yertai Tanai

We model two-period closed-loop supply chain for consumer returns in a retailer setting, in which products can be sold quickly after processing. Taking processing delays into account, we formulate stochastic price-dependent demand and develop a profit maximization model for the entire time horizon.

■ MD93

S- Grand Ballroom B

Joint Panel MIF/DEI: Diversity Statements and Beyond

Sponsored: Minority Issues

Sponsored Session

MIF/DEI: Diversity Statements and Beyond

Shengfan Zhang, University of Arkansas, Department of Industrial Engineering, Fayetteville, AR, 72701, United States

Karen T. Hicklin, University of North Carolina at Chapel Hill, Campus Box 7411, Chapel Hill, NC, 27599-7411, United States

Research shows that diverse environments enrich the educational experience, strengthen communities and workplaces, and promote a healthy society. In recent years many academic institutions have made it common practice to include a diversity statement in their application process for faculty candidates. The Minority Issues Forum and Diversity, Equity, and Inclusion committee present a panel discussion on the importance of diversity statements and the subsequent initiatives that follow to promote workplaces that are inclusive and enriched with varying perspectives, experiences, and capabilities.

Panelists

- Cole Smith, Clemson University, 206E Sikes Hall, Clemson, SC, 29634, United States
- Michael P. Johnson, University of Massachusetts Boston, Department of Public Policy & Public Affairs, Boston, MA, 02125-3393, United States
- Julie Simmons Ivy, North Carolina State University, Raleigh, NC, 27695-7906, United States
- Anahita Khojandi, University of Tennessee, Knoxville, TN, 37996, United States
- William Christian, US Dept of Defense, Washington, DC, United States
- Renata Alexandra Konrad, Worcester Polytechnic Institute, School of Business, 100 Institute Road, Worcester, MA, 01609, United States

■ MD94

S- Grand Ballroom C

Location Analysis III

Sponsored: Location Analysis

Sponsored Session

Chair: Necati Aras, Bogazici University, Industrial Engineering Department, Bebek, Istanbul, 34342, Turkey

1 - Tabu Search for Mixed Strength Sensor Location Problems

Rex K. Kincaid, College of William and Mary, Dept of Mathematics, Williamsburg, VA, 23187-8795, United States, rrkinc@wm.edu, Robin M. Givens, Blair D. Sweigart

Location-detection problems in networks are pervasive, e.g. detection of faults in microprocessors or identifying contaminants in ventilation systems. Sensors are placed at node locations that uniquely detect and locate issues in the network. Sensor failures may be caused by extreme environmental conditions or by the act of a nefarious individual. Computational experience with a tabu search metaheuristic for the minimum Open Locating Dominating (OLD) set problem for sensors of varying strengths is reported. Extensions include OLD covering models and metric locating dominating sets.

2 - Locating Dominating Sets for Criminal Network Modeling

Daniel Blair Sweigart, United States Coast Guard, Maple Valley, WA, 98038, United States, Blair.sweigart@gmail.com

Locating dominating-sets (LDS) are network location constructs regarding the placement of sensors such that when an event occurs anywhere in the network it will be detected and its location immediately known by the unique set of sensors that detect it. This work presents ILP formulations to solve real world LDS problems, including a new model that combines Locating Dominating Sets and Identifying Codes, and explores the ILPs' use in monitoring criminal and terrorist networks

3 - Optimization Algorithms for Facility Layout: Applications of Ammunition Support Activities

Yihe Zhuo, Lehigh University, Bethlehem, PA, 18015, United States, yiz916@lehigh.edu, Lawrence V. Snyder, Robert H. Storer, Luis Zuluaga

We investigate optimization algorithms for automating the layout of facilities for Ammunition Support Activities. The optimization considers the amount and hazard class of material to be stored, land restrictions, risk, and stock retrieval times while meeting all separation distance safety requirements (inhabited buildings, public traffic routes, etc.) A mixed-integer model is developed with several objective functions representing different layout patterns. We also develop heuristics to match specific layout preferences and test both approaches on real case problems.

4 - A Network Interdiction Model to Disrupt Human Trafficking Supply Chain Networks

Xiaodan Xie, PhD Candidate, Ohio University, Athens, OH, 45701, United States, xx581716@ohio.edu

This presentation provides a thorough characterization of the human trafficking networks (HTNs) and maps it into a standard supply chain format. An integrated Network Interdiction Model (NIM) is developed to disrupt HTNs. The model's objective is to minimize the cumulative maximum flow of victims. The proposed NIM is tested on two real federally prosecuted human trafficking cases considering partial interdiction of the network. Computation results demonstrate NIM's capability and robustness in providing comprehensive and optimal interdiction results. The study's insights aim to inform and support the anti-trafficking community in developing effective interdiction strategies.

5 - Improving the Operational Resilience in Transportation Networks

Necati Aras, Bogazici University, Industrial Engineering Department, Bebek, Istanbul, 34342, Turkey, arasn@boun.edu.tr, Hande Küçükaydın

We consider a transportation network that is subject to disruptions by man-made attacks, i.e. when some stations and linkages in the network are attacked, then significant deterioration is observed in the service provision capability. We develop a trilevel Operator-Attacker-Operator model, where the first-level player is the system operator who wants to determine the components that must be protected to increase the operational resilience of the network, the second-level player is the virtual attacker who wants to cause the most disruption by interdicting the components, and finally the third-level player is the system operator who tries to reorganize the flow on the transportation network.

■ MD95

S- Grand Ballroom D

Economics

Contributed Session

Chair: Kathy Jung, University of Washington, Seattle, WA, 98101, United States

1 - Management and Innovation: Evidence from Randomized Experiments and Repeated Surveys in Vietnam

Yuki Higuchi, Associate Professor, Nagoya City University, Nagoya, Japan, yukihiguchi.wachi@gmail.com

We conducted randomized experiments to provide management training for 312 Vietnamese small manufacturers in 2010 and repeatedly collected follow-up data in the span of eight years. Analyzing panel data constructed from our original surveys with negligible incidence of attrition (less than 2 percent of the baseline sample), we find that our training sustainably improved management quality of the treated entrepreneurs. Such improved management spurred innovation by the quality improvement of an existing product. As a consequence, the treated entrepreneurs were 17 percentage points more likely to continue business and continued to have significantly higher business performance.

2 - Is the Seamless Connection the New Monopoly Leverage?

Esma Koca, Imperial College London, London, United Kingdom

We consider the release of a new product category when two asymmetric firms engage in price and quality competition. Ecosystem firm has the leverage of previous market coverage while the rival is new to the market. We investigate if ecosystem leverage keeps the rival at bay and decreases the innovation.

3 - Study on the Influence of the Development of Modern Service Industry on the Regional Economic Differences in China

Yan-Jun Hu, Beijing Union University, Beijing, China, gltyanjun@buu.edu.cn, Xin-Yue Zhang

Based on a classic economic growth model, this paper adopts the method of spatial econometrics, using the panel data of 2003-2016 to analyze the impact of the development of modern service industry on the economic differences among China's 31 provinces, autonomous regions and municipalities from the industrial scale and efficiency, industrial structure and system, industrial function and innovation, as well as industrial base and environment of modern service industry. The results show the indirect factors of the development of modern service industry, such as industrial innovation conditions, market potential and development environment, have a great impact on the growth of regional economy.

4 - Eco-efficiency and Industrial Agglomeration in China

Wenping Wang, Southeast University, Nanjing, China, wpwang@seu.edu.cn, Peiyi Yao, Lihua Wu

In this paper, we analysis how industrial agglomeration affects eco-efficiency by a panel data model from prefecture-level cities of China during the 2004-1017 period. We find industrial agglomeration has positive effect on improving eco-efficiency. Also, eco-efficiency of cities gradually increase during the study period. Cities in the optimizing development zone has higher eco-efficiency than those of the key development zone and the ecological development zone.

5 - Market Entry Strategies for City-based Platforms

Qing Wei, Clemson University, Fargo, ND, United States, qwei@clemson.edu

This paper studies the entry strategies of two competitive multi-sided platforms into segregate markets. We focus on two questions: 1) the conditions to be the market leader; 2) what factors are affecting the market structures. We simulate a two-player game and find that multi-sided platform by its nature is more likely to be concentrated. Also, high network effect and high switching cost may result in a natural monopoly, especially in small markets. And the largest market plays a crucial rule in the competition, if a player loses the opportunity to capture the largest market first, it may have to raise a huge amount of initial fund to overcome its disadvantages in the later competition.

6 - Spatial Search Friction and Allocative Efficiency in the Free-floating Car-sharing Industry

Kathy Jung, University of Washington, Seattle, WA, United States

Free-floating car-sharing services have revolutionized the car-sharing service by allowing users to pick up a car wherever and whenever they want and leave them anywhere. However, there are market allocation issues - there are unused cars in one place when people are looking for cars in other places. To better understand the market condition and estimate welfare, I build a dynamic spatial model using trip information data from ReachNow, a car-sharing company based in Seattle, from its launch in April 2016 to October 2018. I show the presence of search friction and inefficiency by incorporating two distinct market characteristics: consumption-as-supply and usage-based fixed-pricing scheme.

Tuesday, 7:30AM - 9:00AM

■ TA01

CC- Room 201

High-Dimensional Data Analytics: Methodology and Applications

Sponsored: Data Mining

Sponsored Session

Chair: Tianyi Lin

1 - Bidding and Allocation for Demand Side Platforms in Online Advertising

Alfonso Lobos, UC Berkeley, IEOR, Berkeley, CA, 94720, United States, alobos@berkeley.edu, Jose Blanchet, Aaron Flores, Neil Lien

In programmatic advertising, Demand Side Platforms (DSPs) acquire impression opportunities on behalf of advertisers by bidding on exchanges from Supply Side Platforms (SSPs). DSPs are facing important challenges as many SSPs have shifted their auction mechanisms from second to first price auctions. In this talk, we will give a practitioner perspective on the bidding an allocation that DSP faces putting special emphasis in that our allocation system can be seen as internal auction mechanisms. Some optimality results are discussed.

2 - Sparsemax and Relaxed Wasserstein for Topic Sparsity

Zhiyue Hu, University of California, Berkeley, Berkeley, CA, 94720, United States, zyhu95@berkeley.edu

Topic sparsity is the observation that individual documents usually focus on several salient topics, and a real topic also adopts a narrow range of terms. As topic sparsity in online social media increases, so does the difficulty of analyzing the online text sources using traditional methods. In this paper, we propose two novel neural models by providing sparse posterior distributions over topics based on the Gaussian sparsemax construction, and infer the variational distribution with the relaxed Wasserstein (RW) divergence. Experiments on different genres of large text corpora have demonstrated the effectiveness of our approaches as they outperform both probabilistic and neural methods.

3 - Leveraging Molecular Data in Drug Discovery Using Count Statistics

Zoe Vernon, PhD Student, University of California, Berkeley, Berkeley, CA, 94720, United States, zoe_vernon@berkeley.edu, Haiyan Huang, Yuting Ye, Bin Chen

Previous research has shown that drugs which reverse the expression across many disease associated genes have potential to be efficacious for treating the disease in question. Statistics that summarize this reversal require detection of local negative dependency at the extremes of the disease and drug expression profiles. We propose a rank based count statistic designed to detect these local dependencies that is robust to outliers and addresses issues that arise with other measures in this field.

4 - Dispatching Policies for Elevators in a High-Rise

Jiung Lee, University of California, Berkeley, Berkeley, CA, 94720, United States

We study a design and control problem for elevator systems in modern high-rises. We formulate a dynamic control problem for elevator dispatching, and propose a novel control policy based on simulation and queueing theory. We analyze its performance given traffic patterns, and compare the performance with that of the benchmark used in practice.

5 - Discrete-time Hawkes Model on Consumer Behavior: An Example of Yuebao-alibaba

Yuqian Xu, University of Illinois at Urbana-Champaign, Champaign, IL, 61820, United States, Lingjiong Zhu

In this paper, we propose a discrete-time hawkes process model to estimate a general class of data with two key properties. First, the underlying variable has either self-exciting or mutually-exciting property, i.e., the past events affect the future events. For instance, such a variable could be a measure of consumption, demand, default, etc. Second, only aggregated-level data are available.

■ TA02

CC- Room 202

Data Mining for Sustainable Transportation

Sponsored: Data Mining

Sponsored Session

Chair: Mustafa Lokhandwala

1 - Understanding the Impact of Heterogeneous Rider Preferences on a Shared Autonomous Vehicle System

Mustafa Lokhandwala, Purdue University, West Lafayette, IN, 47906, United States, mlokhand@purdue.edu

In a ride sharing system, riders may have varied behaviors in seeking shared or non-shared rides. This study segments the riders in a ride sharing system into five types (non-sharing only, non-sharing preferred, indifferent, sharing preferred, and sharing only) based on their sharing preferences. We use an agent-based model to simulate these preferences in a system of shared autonomous vehicles. The results show that higher service level is achieved when all riders in the system are open to sharing. The maximum service level is achieved when there is a 30\% proportion of sharing only riders with 70\% of sharing preferred or indifferent riders.

2 - Factors Influencing Electric Bike Share Ridership: Analysis of Park City, Utah

Yi He, Utah State University, LOGAN, UT, United States

In recent years, bike share programs have become increasingly popular. Electric bike sharing, however, remains in the early stages of development. In this paper, we analyzed the historical data of the electric bike share system (e-BSS) in Park City, UT, presented the system's performance experience and evaluated the user characteristics and travel behavior, and performed a Poisson regression analysis to investigate the factors that influence the e-bike share usage of this e-BSS. The findings of this paper can help the operators of Summit Bike Share to better understand their users and their e-BSS, while also providing a guide for other e-bike projects currently in the planning stages.

3 - Online Rebalancing Algorithms for Electric Car-sharing Systems

Theodoros Pantelidis, New York University, Brooklyn, NY, United States, tpp254@nyu.edu

Carsharing services have been shown to be effective in reducing numbers of cars on the road unsustainable in some cities. However, such services present a challenge both financially and operationally. The reason is that one-way carsharing systems require some degree of rebalancing to be effective in meeting demand, depending on the service area covered and demand patterns. This operational constraint is further exacerbated in EV systems that have an additional requirement to rebalance vehicles for charging. In this study we present an online heuristic algorithm to provide efficient rebalancing for large systems using data obtained from the BMW ReachNow car sharing system in Brooklyn, New York.

4 - Demand Prediction for Bike Share System Expansion and a Modeling Framework to Evaluate System Performance: A Case Study of Chicago

Zhaoyu Kou, Purdue University, West Lafayette, IN, 47906, United States, kouz@purdue.edu, Hua Cai

During the process of implementing and operating the bike share system (BSS), bike shortage causes unsatisfied demand, while bike oversupply also leads to wasted resources. This study builds a modeling framework to estimate the bike share demand and determine the required bike supply. A random forest model is trained for the demand prediction for expanded area, which helps evaluate the potential to further expand the system. We determine the bike supply through system simulations with the consideration of bike rebalance and parking behaviors. The framework proposed in this study will serve as a tool for the system operators to evaluate system performance, determine system type and bike supply.

■ TA03

CC- Room 203

Data Mining and Medicine / Healthcare: A Mutually Beneficial Relationship

Sponsored: Data Mining

Sponsored Session

Chair: Evangelos Triantaphyllou

Co-Chair: Juri Yanase

1 - Generalized Additive Model with Neural Corrections - Learning Interpretable Main Effects in Healthcare Applications

Tong Wang, University of Iowa, Iowa City, IA, 52245, United States, tong-wang@uiowa.edu

Interpretability of a model is of critical importance in healthcare applications. This work addresses the collaboration of an interpretable model and a black-box model, where an interpretable model captures the main effects and the black-box model adds corrections that are orthogonal to the main effects. Here we choose generalized additive models as the interpretable component, that characterize individual contributions from each variable. The two models are jointly trained with the objective of minimizing error, model complexity, as well as the contribution from the neural network.

2 - Tracking Sepsis Progression: Development and Validation of a Dynamic Rule-based Phenotyping Using Longitudinal Electronic Health Records

Joseph Kapena Agor, Oregon State University, Corvallis, OR, 27606, United States, agorj@oregonstate.edu

Electronic Health Record (EHR) data analysis and modeling requires techniques for population selection and identification of health states during a patient visit. To overcome the challenge of limited information in an EHR, we propose a dynamic phenotyping algorithm to track the progression of sepsis. We apply the algorithm to two EHR datasets and the results show high sensitivity regarding identification of true sepsis visits. Moreover, we apply the Recent Temporal Pattern (RTP) mining model classification model and compare against prediction performance where ICD-9 codes are used as a ground truth showing that the proposed phenotyping is superior in performance.

3 - Predicting Length of Stay of Emergency Department Patients and its Implications for Operations Management

Yuan Zhou, University of Texas at Arlington, Arlington, TX, 76019, United States, yuan.zhou@uta.edu, Chen Kan, Wang Hao, Eniola Suley

Excessive length of stay (LOS) of emergency department (ED) patients has detrimental effects on ED operations (e.g., increased crowding level and resource consumption), patient outcomes (e.g., care delays), and hospital costs. To reduce the ED burden, proactive approaches that enable accurate LOS prediction during the early stage of ED encounters are urgently needed. This study utilizes ensemble learning classifiers coupled with majority voting selection to predict patients with excessive LOS at the triage stage. An intervention that allows re-locating those patients to a 'virtual' unit outside the ED is evaluated based on hourly ED crowding level changes and daily work hours saved.

4 - Aiding the Prescriber: a Machine Learning Approach to Personalized Risk Modeling for Chronic Opioid Therapy

Margret V. Bjarnadottir, University of Maryland, College Park, MD, margret@rhsmith.umd.edu, David Anderson, Ritu Agarwal, Kislaya Prasad, Al Nelson

The opioid crisis has assumed center stage in recent US health policy debates and discussions. While multiple factors may have contributed to the crisis, the widespread availability of opioids, fueled by physician prescribing patterns, diversion of prescribed medications, and the interaction of these factors with potential illicit opioid use, have been implicated as proximal causes for subsequent opioid dependence and mortality. In this talk we focus on how machine learning models can aid physicians in their prescription decisions with the goal of reducing high risk and/or unnecessary prescriptions.

5 - The Overdiagnosis Problem in Medicine: A Challenge for Medical and Computer Science Professionals Alike

Evangelos Triantaphyllou, Louisiana State University, Division of Computer Science & Engineering, Baton Rouge, LA, 70803, United States, etriantaphyllou@yahoo.com, Juri Yanase

Overdiagnosis in medicine is a complex and controversial issue. It is related to many serious medical conditions and diseases, such as various types of cancer. We demonstrate that even small amounts of overdiagnosis may inflate perceived benefits, such as improving survival rates. Many factors contribute to the emergence of this problem. More medical research is needed. However, data mining (DM) may offer a crucial way for helping to reduce overdiagnosis. We conjecture that overdiagnosed cases lie on or near the border of different diagnostic classes. Thus, new types of DM methods must be developed that are accurate on data that lie on or near the border between different diagnostic classes.

■ TA04

CC- Room 204

Joint Session DM/Practice Curated: Data Mining & Analytics in Emerging Marketing Ecosystem - B

Sponsored: Data Mining

Sponsored Session

Chair: Ankur Jain

1 - Data is Not Everything!

Pradeep Kumar, Foote, Cone & Belding - Interpublic Group, Chicago, IL, United States, Pradeep.Kumar@fcb.com

Data combined with imagination can be extremely powerful. Not just for the analysts but for an entire enterprise to practice data fueled strategy and creativity. This session will bring the stimulus to discuss: how we deploy various techniques including machine learning to fuel strategy and creativity. use cases with structured and unstructured data sources - numeric, text, images and video how imagination makes Strategic Analytics a connective tissue for the organization Raw data is an oxymoron. Diverse mindsets and skillsets with pronounced curiosity makes it purposive.

2 - Revenue Management for Shopper Marketing Campaign Management

Ronald P. Menich, Catalina Marketing Corporation, Atlanta, GA, United States, Ronald.Menich@catalina.com

Shopper marketing at Catalina includes the delivery of media to grocery, drug store, and other retail shoppers, media such as coupons and advertisements, via print, digital, and other channels, funded by brand, manufacturer, or retail customers. It is of interest to Catalina and to its customers to forecast in advance the size of audience to be reached by an offer, the expected number of impressions or prints, the expected number of redemptions or responses, and a variety of related financial measures. This session discusses how a variety of interacting data science models are combined to create a responsive Revenue Management Forecasting capability, applicable both pre-campaign and in-flight.

3 - Promotional Programs in the context of Toll Roads/Managed Lanes

Vamsi K. Nadimpalli, Director of Analytics, Cintra US Services LLC, Austin, TX, United States

Targeted unpublished promotional programs is a relatively new application within the context of huge infrastructure projects like toll roads/ Managed Lanes. In this talk we discuss how different targeted promotions appeal to different types of toll road customer segments. We will also explore optimization based experimental design techniques that are well suited to efficiently measure the impact a promotions on customers usage of toll roads.

■ TA05

CC- Room 205

Combatting the Epidemic: Opioid Data Integration & Mining

Sponsored: Data Mining

Sponsored Session

Chair: Matthew Hudnall

1 - Prescriber and Pharmacy-Sharing Effect on Prescription Opioid Abuse: A Large-Scale Social Network Analysis

Yongcheng Zhan, Tucson, AZ, 85719, United States, Bin Zhang

Recent years have observed the spread of America's drug overdose epidemic. The implementation of the prescription drug monitoring program (PDMP) helps fight against the problem. However, it was reported that the impact of PDMPs remained nascent and inconsistent. We used innovative social network analysis techniques to study PDMP data in Arizona state. We found that there existed statistically significant network effect on patients' opioid high-dose status, which means sharing prescribers or pharmacies with other opioid high-dose patients was positively related to the high-dose status of the patients themselves.

2 - Aiding the Prescriber - Machine Learning for Decision Support

Margret Bjarnadottir, University of Maryland, College Park, MD, United States, margret@rhsmith.umd.edu

The opioid crisis has assumed center stage in recent US health policy debates and discussions. While multiple factors may have contributed to the crisis, the widespread availability of opioids, fueled by physician prescribing patterns, diversion of prescribed medications, and the interaction of these factors with potential illicit opioid use, have been implicated as proximal causes for subsequent opioid dependence and mortality. In our work we focus on how machine learning models can aid physicians in their prescription decisions with the goal of reducing high risk and/or unnecessary prescriptions.

3 - Prescribing Patterns and Adherence of Suboxone in Massachusetts

Md Noor-E-Alam, Northeastern University, Boston, MA, United States, mnalam@neu.edu

In recent years, the addiction and abuse of prescription opioids has reached an epidemic level in the US. This epidemic worsens health, drains productivity, and procreates crime; communities suffer significant direct and indirect losses. Given this public health emergency, immediate actions are required to make communities resilient against the opioid addiction epidemic. To that end, we aim to strengthen community resilience to combat the opioid crisis through developing a risk assessment tool to help physicians generate personalized opioid prescriptions for patients, which will help reduce the flow of opioids and minimize a patient's probability of addiction and overdose.

4 - Discussant

Jason Parton, University of Alabama

■ TA06

CC- Room 209

Randomized and Distributed Algorithms for Big Data Analytics

Sponsored: Data Mining

Sponsored Session

Chair: Nahid Majlesinasab

1 - A Fast Incremental Mirror Descent Method for Finite Sum Problems on Semidefinite Matrix Spaces

Nahid Majlesinasab, Oklahoma State University, Stillwater, OK, 74078, United States, nahid.majlesinasab@okstate.edu, Farzad Yousefian

We consider a finite sum problem where the goal is to minimize the summation of convex objectives on semidefinite matrix spaces. This type of minimization arises in problems such as sparse inverse covariance estimation. Despite the recent advancements in first-order methods addressing problems over vector spaces such as SAG and SAGA, there seems to be a major gap in the theory of the first-order methods for finite sum problems on semidefinite matrix spaces. Motivated by this gap, we develop a fast incremental mirror descent method. We show that the iterates generated by the algorithm converge to an optimal solution. Using a suitably defined error function, we derive a convergence rate statement.

2 - Randomized First-order Methods for Ill-posed Cartesian Variational Inequality Problems

Harshal Kaushik, Oklahoma State University, Ind, Stillwater, OK, 74078, United States, harshal.kaushik@okstate.edu, Farzad Yousefian

Motivated by multi-user optimization problems and non-cooperative Nash games, we consider Cartesian variational inequality problems (VI). To address ill-posedness in this regime, we consider the problem of minimizing a desired objective function over the solution set of the Cartesian VI. We develop a randomized block coordinate iterative regularized gradient method where at each iteration, a block is randomly selected and the iterate is updated at that block. We establish the almost sure convergence of the generated sequence by the scheme. In the case of merely monotone VIs, we derive a convergence rate in terms of a suitably defined gap function. Preliminary numerical results will be presented.

3 - Rate Analysis for Variance-reduced Stochastic Quasi-newton Schemes for Stochastic Convex Optimization

Afrooz Jalilzadeh, Pennsylvania State University, University Park, PA, 16801, United States, Azj5286@psu.edu, Angelia Nedich, Uday Shanbhag, Farzad Yousefian

This paper presents a quasi-Newton framework that can process merely convex and possibly nonsmooth (but smoothable) stochastic convex problems. (i) In strongly convex regimes with state-dependent noise, the proposed variable sample-size stochastic quasi-Newton (VS-SQN) scheme admits a non-asymptotic linear rate of convergence. In nonsmooth regimes, using Moreau smoothing the method retains the linear convergence rate. (ii) In merely convex but smooth settings, the regularized VS-SQN scheme displays a rate of O(1/k1-) while in nonsmooth regimes, the rate worsens to O(k-1/3). Such statements allow for a state-dependent noise under a quadratic growth property on the objective.

4 - Distributed Inference Over Networks: Geometrically Convergent Algorithms and Statistical Guarantees

Ying Sun, Purdue University, West Lafayette, IN, 47906, United States, Ye Tian, Gesualdo Scutari, Guang Cheng

In this talk, we present a decentralized projected gradient algorithm for solving high-dimensional convex ERM problems. We provide a sample-iteration complexity analysis and show that under the restricted strongly convex/smoothness conditions on the global loss function the algorithm converges at a linear rate to the statistical precision of the model, provided that the network is sufficiently connected. Our result also reveals an interesting tradeoff between the hardness of the problem and network connectivity on the impact of convergence rate: a problem with more scattered samples requires a more connected network to keep the rate invariant.

5 - First-order Augmented Lagrangian Method (iALM): Nonergodic Convergence and Iteration Complexity

Zichong Li, Rensselaer Polytechnic Institute, Troy, NY, United States, Yangyang Xu

Augmented Lagrangian method (ALM) is popular for solving constrained optimization problems. The global convergence rate of inexact ALM is open for problems with nonlinear inequality constraints. In this paper, we work on convex programs with both equality and inequality constraints. We first establish some important properties of the augmented dual function, Then we establish the nonergodic convergence rate of inexact proximal point method (iPPM). Later we establish the relation between iALM and iPPM, establish the global nonergodic convergence rate of iALM and estimate its iteration complexity. Finally we compare our results with existing works.

■ TA07

CC- Room 210

Business Applications of Data Science

Sponsored: Data Mining

Sponsored Session

Chair: Abhinav Maurya

1 - Inferring Semantic Hierarchies from Taxonomic Curation at Pinterest

Emaad Manzoor, Carnegie Mellon University, Pittsburgh, PA, 15213, United States, emaad@cmu.edu

Curated taxonomies enhance the performance of machine-learning systems via high-quality structured knowledge. However, manually curating a large and rapidly-evolving taxonomy is infeasible. In this work, we propose Arborist, an approach to automatically expand textual taxonomies by predicting the parents of new taxonomy nodes. Arborist handles the more challenging scenario of taxonomies with heterogenous edge semantics that are unobserved, and also provides example-based explanations. We evaluate Arborist on a large-scale taxonomy at Pinterest and demonstrate up to 60% in mean reciprocal rank and 80% in recall@15.

2 - Don't Classify, Translate: Multi-level E-commerce Product Categorization via Machine Translation

Stanley Kok, National University of SIngapore (NUS), Singapore, Singapore, stanley.kok@nus.edu.sg

E-commerce platforms categorize their products into a multi-level taxonomy tree with thousands of leaf categories. Conventional methods for product categorization are typically based on classification algorithms. These algorithms take product information as input to classify a product into a leaf category. We propose a new paradigm based on machine translation. In our approach, we translate a product's natural language description into a sequence of tokens representing a root-to-leaf path in a product taxonomy. In our experiments on two real-world datasets, we show that our approach achieves better predictive accuracy than a state-of-the-art classification system.

3 - Missing Not at Random in Matrix Completion: Debiasing Guarantees From Estimating Missingness Probabilities under Low Nuclear Norm Structure

George H. Chen, Assistant Professor, Carnegie Mellon University, Pittsburgh, PA, 15213, United States, Wei Ma

Matrix completion is often applied to data where entries are missing not at random. For example, in a recommendation system, if users tend to only reveal ratings for items they like then the revealed entries can have a positive bias. In this case, matrix completion methods relying on revealed entries being uniformly sampled can yield overly optimistic predictions of unseen user ratings. In this paper, we propose a new approach for debiasing standard matrix completion losses via estimating probabilities of entries being revealed using low nuclear norm structure. We develop theory for this approach and show that it outperforms a number of baselines in practice.

4 - Predicting Cryptocurrency Movement: Analysis of Blockchain Transaction Graph

Yuxin Zhang, University of Texas at Austin, Austin, TX, United States, yuxin.zhang@utexas.edu, Rajiv Garg, Patrick L. Brockett, Linda Golden

In this paper, we propose an iterative learning model to predict the evolution of blockchain transactions based on its entire transaction history. We study patterns of transaction subgraphs and use those to predict volume and amounts of transaction graphs in future blocks. Furthermore, we develop the insights to predict the exchange rate for the cryptocurrency using the identified transaction subgraphs. We demonstrate this framework in the context of Bitcoin and discuss the generalizability for other cryptocurrencies. Additionally, we provide discussion on how framework is valuable in understanding anomalies in blockchain enabled supply chain.

■ TA08

CC- Room 211

Industrial Applications of Artificial Intelligence and Machine Learning

Emerging Topic: Artificial Intelligence & Machine Learning

Emerging Topic Session

Chair: Young M. Lee, Johnson Controls, Milwaukee, WI, 53202, United States

1 - Applying Artificial Intelligence to Smart Built Environment

Young M. Lee, Johnson Controls, Milwaukee, WI, 53202, United States, young.m.lee@jci.com, Youngchoon Park, Sudhi Sinha

In smart built environment, equipment and systems such as chillers, boilers, air handling unit, rooftop unit, refrigeration units, energy storage system, security systems, assurance services systems and smart experience systems are equipped with sensors, are connected to each other, and generate real time data. AI analytics then use the data to make buildings safe and cost-effective, and make people more comfortable and productive. This talk describes AI analytics in built environment and how they are helping in reducing maintenance costs, reducing energy costs, improving the life of equipment, improving service level and improving security, comfort and productivity of building occupants.

2 - Automated Vibration Analysis with Convolutional Neural Networks

Kelsey Schuster, PhD, Johnson Controls, Milwaukee, WI, United States

Vibration analysis is an important diagnostic tool for identifying mechanical issues in rotating equipment. Typically, technicians collect vibration data on-site, and trained vibration analysts evaluate each dataset to identify potential issues so they can be corrected before serious damage occurs. We find that leveraging convolutional neural networks to identify abnormalities in vibration signals can automate a portion of this analysis, allowing vibration analysts to focus only on suspected faulty equipment and more efficiently evaluate data. Using historical chiller data, we find that we can identify all critical abnormalities while passing through 30% of acceptable machines.

3 - Statistical Modeling of Large-scale Repairable System Reliability Data in Big Data Environment

Xiao Liu, PhD, University of Arkansas, Fayetteville, AR, United States, xl027@uark.edu, Rong Pan

Leveraging the power of modern statistical learning, this paper investigates a statistical approach which integrates the additive-tree methods (Random Forests and Boosting) and the classical data analysis methodologies for repairable system reliability, such as the nonparametric estimator for the Mean Cumulative Function and the parametric models based on the Nonhomogeneous Poisson Process.

4 - Deep Learning to Predict Building and Sub-Meter Energy Consumption

Sugumar Murugesan, PhD, Johnson Controls, Santa Clara, CA, United States, sugumar.murugesan@jci.com, Young M. Lee

We present our experience developing energy prediction models for various JCI buildings. We focus on LSTM (Long Short-Term Memory) Sequence-to-Sequence (S2S) architectures, which are well-suited for capturing temporal dynamics in energy signals. Within LSTM S2S context, we report observations such as - impact of temporal memory, deterministic predictors, realized and forecasted weather, and mismatched holidays, followed by performance evaluation and comparison with ASHRAE guidelines. We conclude our presentation with discussion on ongoing efforts to build probabilistic predictions, domain adaptation to achieve 'deploy-and-then-learn' for new buildings.

5 - Economically Driven Adaptive Traffic Signal Control

Shan Jiang, PhD Student, Rutgers University, Piscataway, NJ, United States, sj576@rutgers.edu, Mohsen Jafari, Yufei Huang

This paper proposes an Economic Adaptive Traffic Signal Control model. The model uses a penalty function that grows with vehicle waiting time according to a continuous compounding economic model, with interest rate that varies with traffic flow. Each signal controller is assumed an intelligent agent seeking to minimize the total penalty it pays to vehicles that pass through. The agent control problem is formulated as a Markov Decision Process and Deep Q Network is utilized to solve it. The agent adopts an optimal control policy for signal timing and interest rate as functions of traffic state. A VISSIM simulation model with classic four-leg signalized intersections is used to demonstrate the model.

■ TA09

CC- Room 212

Sustainable Supply Chains

Sponsored: Artificial Intelligence

Sponsored Session

Chair: Fahimeh Rahmanniyay

1 - A New Forecasting Model Selection in Supply Chain Management: Application to MonarchFx Inc.

Sajjad Taghiyeh, North Carolina State University, Raleigh, NC, United States

Selecting the most accurate forecasting model for a given time series has complex decision. The application of machine learning algorithms in model selection has emerged as a promising approach. We propose a new time series forecasting model selection procedure based on intermediate classification (MSIC). Our method trains the classification models using train and validation sets and predicts out-of-sample performance by the trained classifier. Proposed method has been adopted and applied to data provided by MonarchFx (a distributed logistics solutions provider). These findings suggest that our proposed selection approach results in more robust predictions with lower mean squared errors.

2 - Who Wants Green Jeans? A Dynamic Model of Publicity and Reputation

Susan A. Slotnick, Cleveland State University, Cleveland, OH, United States, s.slotnick@csuohio.edu, Monire Jalili

A firm produces two types of products (standard and green) and serves two types of customers (base and environmentally conscious). The production cost of the green product is higher than the production cost of the standard product, and the firm's expenditures on publicity serve to enhance its reputation for environmental responsibility over time, which broadens its market share and increases demand for both products. We investigate the trade-off between expenditures on sustainable products and publicity, and the potential for increased profit due to enhancement of the firm's reputation.

3 - Blockchain Technology and its Applications for The Supply Chain Management in the Food Industry

Jinwook Lee, Assistant Professor, LeBow College of Business, Drexel University, Philadelphia, PA, United States, jl3539@drexel.edu

Since the inception of blockchain and Bitcoin (Nakamoto (2008)), a decentralized-distributed network and its associated cryptocurrency, respectively, the world has witnessed a slew of newer adaptations and applications. Although the original distributed ledger technology (DLT) of blockchain is deemed secure and decentralized, the confirmation of transactions is inefficient by design. We introduce an efficient and secure DLT by reconstructing the chain of antichains given a DAG-pool of transactions. Further, we apply the conceptual "hybrid database" to DLT-augmented supply chain transparency in the food industry. Detailed real-life applications are presented.

4 - Analyzing the Sustainability Performance Indicators of Firms in the Indian Context Using Grey Theory

Rajesh Rajagopal, Assistant Professor, ABV-Indian Institute of Information Technology and Management, Gwalior, India, rajeshambzha@gmail.com

Sustainability enables the present supply chains to stabilize their gains. Here, we study the sustainability performances of 39 firms in the Indian context, listed in the Thomson Reuters ESG (Environmental, Social, and Governance) scores for a period of 5 years from 2014 to 2018. A grey incidence analysis is used to study the most important themes contributing to the sustainability performances. It is observed from the results that the Resource use score and the Environmental innovation score, emerges as the most important themes of ESG performances of Indian firms. And the research uncovers implications in the direction to improving the Governance performance of Indian firms.

5 - A Framework for Sustainable Supply Chain Management and Associated Construct Measurements

Xianghui (Richard) Peng, Assistant Professor, Penn State-Erie, The Behrend College, Erie, PA, United States, xzp17@psu.edu, Lu Xu, Ying Cao, Victor R. Prybutok

A thorough literature review on sustainable supply chain management (SSCM) shows that SSCM practices require additional investigation and refinement of the concepts. Construct measurements and framework development appear particularly needed in the SSCM literature. This research identifies and substantiates key SSCM practices. The key practices are then related to constructs that allow development of a SSCM framework. This research contributes to the theory development for SSCM.

■ TA10

CC- Room 213

Developing Analytics Talent and Culture

Sponsored: Analytics

Sponsored Session

Chair: Aaron Burciaga, Analytics2Go, Tysons, VA, 22102, United States

1 - Using the INFORMS Analytics Capability Evaluation to Support Organizational Change and Analytics Capability Improvements

Walter Degrange, Cana Advisors, Chapel Hill, NC, United States, Norman Reitter

Are you wondering about how to determine the level of analytics capabilities that you need to meet your organization's needs? Do you have an approach that will help you and your organization set a path towards improvement? The INFORMS Analytics Capability Evaluation (ACE) initiative provides you the tools and coaches that you will need to get started. This presentation reviews the INFORMS ACE initiative - including the INFORMS standard for measuring analytics capability and a new Analytics Coaching program. We also talk about tips for performing your organizational level assessment and lessons that we have learned from facilitating analytics assessments to date.

■ TA11

CC- Room 214

Improving Patient Flow and Quality of Care

Sponsored: Applied Probability

Sponsored Session

Chair: Pengyi Shi, Purdue University, West Lafayette, IN, 47907, United States

Co-Chair: Nan Liu, Boston College, Chestnut Hill, MA, 02467, United States

1 - Improving Patient Flow in Emergency Departments via Hospital Bed Requests at Triage

Serhan Ziya, University of North Carolina, Department of Stat and OR, 356 Hanes Hall Cb#3260, Chapel Hill, NC, 27599, United States, ziya@unc.edu, Wanyi Chen, Sukriye Nilay Argon

In this paper, with the objective of reducing patients' length-of-stay in emergency departments, we consider the possibility of requesting hospital beds at the time of triage for patients who are predicted to have a high probability of being admitted to the hospital. We develop practical methods based on queueing theory and Markov decision processes and investigate the performances of the proposed methods with a simulation study.

2 - Optimal Allocation of Rehab Beds to Acute Care Patients

Berk Gorgulu, University of Toronto, Toronto, ON, M5J 1B7, Canada, bgorgulu@mie.utoronto.ca, Vahid Sarhangian

Due to limited rehab bed capacity, patients requiring rehab after their acute care often need to wait, occupying a bed and other resources in the acute part of their care. In this work, we propose a data-driven approach for optimal allocation of rehab beds to acute care patients with the goal of improving patient flow and reducing waiting times.

3 - An Equilibrium Framework for Assessing the Impact of Policy Changes under Endogenous Patient Choice

A. Cem Randa, University of Chicago, Booth School of Business, Chicago, IL, 60637, United States, randa@chicagobooth.edu, Baris Ata, John Friedewald

This paper develops an equilibrium framework for assessing the impact of the deceased-donor kidney allocation policy on the transplant candidates' organ acceptance behavior, the transplant waitlist, organ availability for different patient groups and organ wastage. We advance a fluid model of the transplant waitlist and a dynamic structural model of the transplant candidates' accept/reject decisions for organ offers. Taking the quality adjusting scores of deceased-donor kidney transplant candidates as an input to our model, we perform counterfactual studies using our equilibrium framework to assess the performance of so called borderless distribution of deceased donor kidneys.

4 - Analysis of Hospital Networks via Time-varying Fluid Models with Blocking

Noa Zychlinski, Columbia Business School, Israel, NYC, NY, 34354, United States, nz2307@columbia.edu, Avishai Mandelbaum, Petar Momcilovic, Izack Cohen

Bed-blocking has become a challenge to healthcare operators due to its economic implications and quality-of-life effect on patients. This motivated us to model and analyzes the flow of patients between hospitals and geriatric institutions in order to improve their joint operation. We develop a fluid model, which accounts for blocking, mortality and readmission — all significant features of the discussed environment. Then, for bed allocation decisions, we analyze the fluid model and its offered-load counterpart. Solving for the optimal number of geriatric beds in our system demonstrates that significant cost reductions are achievable, when compared to current operations.

■ TA12

CC- Room 2A

Machine Learning and Related Topics

Sponsored: Applied Probability

Sponsored Session

Chair: Amber L Puha, California State University-San Marcos, San Marcos, CA, 92096-0001, United States

1 - Finite-time Performance Bounds and Adaptive Learning Rate Selection for Temporal Difference Learning

R Srikant, University of Illinois at Urbana-Champaign, Coord Science Lab & Dept of ECE, Urbana, IL, 61801, United States, rsrikant27@gmail.com

We derive finite-time performance bounds for TD learning with linear function approximation and a constant learning rate. Then, we use these bounds to design an algorithm to adapt the learning rate to achieve fast convergence. Joint work with Harsh Gupta and Lei Ying.

2 - Fundamental Limits of Learning Adversarially Robust Classifiers

Daniel Cullina, Princeton University, Princeton, NJ, United States, dcullina@princeton.edu

How many training examples are required to learn a classifier that is not only accurate but robust to adversial examples? Does adding the robustness requirement increase this sample complexity? We extend the Vapnik-Chervonenkis framework to robust classification and obtain upper bounds on error rate that depend on a new quantity that is a property of a hypothesis class together with an adversarial constraint relation. We obtain bounds on error rate with unlimited training data via optimal transport. In a Bayesian setting, these translate into finite-sample lower bounds on error rate.

3 - Performance Analysis of Network Inference Algorithms for Bernoulli Autoregressive Processes

Carolyn L. Beck, Professor, University of Illinois Urbana-Champaign, Urbana, IL, 61801, United States, beck3@illinois.edu, Xiaotian Xie, Dimitrios Katselis, R. Srikant

We consider multivariate random processes that produce a vector of Bernoulli signals, and capture binary interactions over network structures; we refer to this paradigm as a Bernoulli Autoregressive (BAR) process. Our main goal is to identify or infer the causal interconnectivity structures of the underlying networks, which we assume are sparsely connected, using time-series data. We discuss sample complexity of MLE and greedy-like algorithms for solving the related inference problem, and note the relation of this complexity to mixing times of general BAR processes, which can be viewed as Markov chains with non-reversible dynamics.

4 - Distributionally Robust Losses Against Mixture Covariate Shifts

Hongseok Namkoong, Stanford University, Stanford, CA, 94305, United States, John Duchi, Tatsunori Hashimoto

Modern large-scale datasets are often collected over heterogeneous subpopulations, such as multiple demographic groups or multiple text corpora. Minimizing average loss over such datasets fails to guarantee uniformly low losses across all subpopulations. We propose a convex procedure that controls the worst-case performance over all subpopulations of a certain size. Our procedure comes with finite-sample optimality guarantees on the worst off subpopulation, and converges at the standard nonparametric rate. Empirically, we observe on lexical similarity and recidivism prediction tasks that our worst-case procedure learns models that do well against unseen subpopulations.

■ TA13

CC- Room 2B

Machine Learning in Finance

Sponsored: Applied Probability

Sponsored Session

Chair: Kay Giesecke, Stanford University, Stanford, CA, 94305, United States

Co-Chair: Markus Pelger, Stanford University, Stanford, CA, 94305, United States

1 - Time-varying Asset Pricing Factors for Stock Returns

Markus Pelger, Stanford University, Stanford, CA, 94305, United States, mpelger@stanford.edu, Zihan Lin

We propose a new method to explain the time-series and cross-section of individual stock returns. Our approach allows for latent factors and time-varying loadings as general functions of time-varying firm characteristics. Our estimator enforces no-arbitrage and links the factor structure in the individual stock return space to a low dimensional structure in the space of non-linear firm characteristic basis functions. Empirically, we outperform models that ignore non-linear characteristic basis functions or neglect the no-arbitrage constraint in the factor extraction.

2 - A Computationally Efficient Significance Test for Machine Learning Models

Enguerrand Horel, Stanford University, Stanford, CA, 94305, United States, ehorel@stanford.edu, Kay Giesecke

We develop a simple and computationally efficient significance test for the feature variables of a machine learning model. Our forward-selection approach applies to any model specification, learning task and variable type. The test is non-asymptotic, straightforward to implement, and does not require model refitting. It identifies the statistically significant features as well as feature interactions of any order in a hierarchical manner, and permits rank-ordering the features according to their influence. Numerical results illustrate its performance.

3 - Estimating the Discount Curve

Ye Ye, Stanford University, Stanford, CA, United States, Damir Filipovic, Kay Giesecke, Markus Pelger

We propose two nonparametric methods for estimating the discount curve from large data sets of coupon bonds, with regularization penalties in terms of the smoothness of the approximating forward curve. We provide analytical solutions for a given regularization weight, and we propose a data-driven approach to determine the optimal regularization penalty that minimizes out-of-sample pricing errors. We apply our methods on a large data set of U.S. Treasury securities from 1961 to present to extract term structure estimates at daily frequency with daily-spaced maturities up to ten years. The resulting term structure estimates match standard benchmarks but have smaller pricing errors.

■ TA14

CC- Room 302

Emerging Topics in Retail Operations

Sponsored: Manufacturing & Service Oper Mgmt

Sponsored Session

Chair: Mehmet Sekip Altug, George Mason University, Washington, DC, 20052, United States

1 - Impact of the Interplay Between Review Number and Rating in Digital Platforms: an Empirical Study

Samayita Guha, Temple University, Philadelphia, PA, United States, samayita.guha@temple.edu, Naveen Kumar, Subodha Kumar, Joydeep Srivastava

Consumers now increasingly depend on user-generated reviews. Based on the data collected from a digital-platform, we empirically examine the impact of interaction between the number of reviews and the average rating.

2 - Drivers of Direct Store Delivery Performance

Arzum E. Akkas, Boston University, Boston, MA, 02142, United States, aakkas@bu.edu, Yasin Alan, Tae-Youn Park

Direct store delivery (DSD) is a common method of sales and delivery in the grocery retail supply chains, in which a vendor delivers its goods directly to retail stores bypassing retailers' distribution centers. Our study empirically examines several factors that impact the performance of DSD operations such as employee characteristics and the vendor's delivery route structure. Our work has important implications for the efficiency of sales and delivery operations, bottom lines of DSD companies, and quality of service provided to retail stores.

3 - Opaque Selling and Last-minute Selling: Revenue Management in Vertically Differentiated Markets

Hang Ren, School of Business, George Mason University, Fairfax, VA, 22030, United States, hren5@gmu.edu, Tingliang Huang

We analyze the performance of opaque selling as a clearance strategy in vertically differentiated markets. Compared to last-minute selling, opaque selling may increase revenue because consumers who wait for the sales cannot choose the preferred product type. Its disadvantage, however, lies in the inflexibility in segmenting different types of consumers. Both the advantage and the disadvantage are radically different from their counterparts in horizontally differentiated markets. This contrast generates opposite policy recommendations across the two settings.

4 - The Impact of Online Product Reviews on Retailers Pricing and Return Policy Decisions

Mehmet Sekip Altug, Associate Professor, George Mason University, Fairfax, VA, 20052, United States, maltug@gmu.edu

Customers feel increasingly more comfortable with posting and using on-line product reviews. In a two-period setting, we explore the impact of product reviews on customer's valuation uncertainty for an experience-type product and how that in turn affects a monopolist retailer's pricing and refund decisions. Surprisingly, we find that the retailer makes its return policy even more lenient. In a duopolistic competition, the overall sentiment of the on-line reviews are influenced by the refund and pricing decisions of both retailers. Interestingly, we show that the retailers make their returns more lenient compared to the monopolist case when they collectively determine the review sentiment.

■ TA15

CC- Room 303

Joint Session MSOM/SERV OP/Practice Curated: Behavioral Queueing Science

Sponsored: Manufacturing & Service Oper. Mgmt/Service Operations

Sponsored Session

Chair: Armann Ingolfsson, University of Alberta, Edmonton, AB, T6G 2R6, Canada

1 - Delay Information on a Ride-sharing Platform: a Large-scale Field Experiment

Qiuping Yu, Georgia Institute of Technology, University of Washington, Business School, Atlanta, GA, 98195-3226, United States, yqp2009@gmail.com, Yiming Zhang, Yong-Pin Zhou

In collaboration with a large ride-sharing platform in China, we study how delay estimates and their progress over time impact customers' abandonment behavior. To do so, we conducted a large-scale randomized field experiment in three Chinese cities in 2018, which covers 2.5 million rides. Not surprisingly, a higher delay estimate increases customers' likelihood to abandon. We find that such an impact increases as the congestion level increases, the progress of the estimates reduces customers' likelihood to abandon, and such impact is the largest in the middle of customers' waiting episodes.

2 - Does What Happens in the Ed Stay in the Ed? The Effects of Emergency Department Physician Workload on Post-ed Care Use

Mohamad Soltani, University of Wisconsin-Madison, Madison, WI, 53706, United States, mohamad.soltani@wisc.edu, Robert Batt, Hessam Bavafa, Brian Patterson

We study the effects of workload in Emergency Department (ED) on post-ED care. First, using an ED patient-level data, we show that attending physicians admit more patients to the hospital when their workload increases. Second, combining the ED data with an integrated health system billing data, we find different effects of physician workload on number of follow-up visits. As workload increases, even after controlling for the changes in the admission decision, the number of follow-up visits increases for the discharged patients but does not change significantly for the admitted patients. We also explore the changes in care provided during the ED visit as the possible drivers of these effects.

3 - Queues with Strategic Arrivals and Strategic Servers

Ragavendran Gopalakrishnan, Assistant Professor, Queen's University, Kingston, ON, Canada

We revisit Naor's seminal study of an observable M/M/1/FCFS queue where arrivals are strategic (with linear utilities) and introduce strategic server behavior. We find that a joint equilibrium between the arrivals and server may not exist, nor be unique when it does exist. Moreover, a socially optimal threshold for the arrivals (as defined by Naor) could exceed an equilibrium threshold, a phenomenon that does not occur in Naor's model (where the server is not strategic). We discuss the consequences of these results in designing optimal policies for service systems involving strategic behavior from both arrivals and servers.

4 - Signaling Quality and Speed Through Staffing Decisions

Park Sinchaisri, The Wharton School, Jon M. Huntsman Hall, Philadelphia, PA, 19104, United States, swich@wharton.upenn.edu, Serguei Netessine

From behavioral viewpoint, longer queue can signal high quality/low prices of the products. On the other hand, shorter queue can be attractive because of promise of a faster service. Using unique data on the people who pass by the small retail stores vs. enter and purchase, we evaluate these two behavioural effects of queuing and demonstrate their impact upon optimal staffing policies in the stores.

3 - Queues with Strategic Arrivals and Strategic Servers

Amy Ward

We revisit Naor's seminal study of an observable M/M/1/FCFS queue where arrivals are strategic (with linear utilities) and introduce strategic server behavior. We find that a joint equilibrium between the arrivals and server may not exist, nor be unique when it does exist. Moreover, a socially optimal threshold for the arrivals (as defined by Naor) could exceed an equilibrium threshold, a phenomenon that does not occur in Naor's model (where the server is not strategic). We discuss the consequences of these results in designing optimal policies for service systems involving strategic behavior from both arrivals and servers.

■ TA16

CC- Room 304

Service Network Design

Sponsored: Manufacturing & Service Oper. Mgmt/Service Operations

Sponsored Session

Chair: Chung-Piaw Teo, National University of Singapore Business School, Singapore, 119245, Singapore

1 - Profit or Market Thickness? Dynamic Order Allocation Mechanisms with a Hybrid Workforce

Eryn Juan He, Institute of Operations Research and Analytics, NUS, Singapore, hej@u.nus.edu, Joel Goh

Several firms have launched their own on-demand platforms to engage freelancers. The emergence of such hybrid workforces raises new unexplored research questions: How should demand be shared between its regular employees of the firm and freelancers from the platform? Under what conditions will such system be sustainable in the long run? We design an optimal dynamic order allocation mechanism to maximize system's long run profit under a service-level constraint and stochastic network effects. We show that as the mean and variance of network effects vary, it can be optimal for the firm and platform to operate collaboratively or independently, the system may either be sustainable or not in the long run.

2 - Stands Assignment in Cargo Airport

Quanmeng Wang, National University of Singapore (NUS), Singapore, e0210515@u.nus.edu, Chung-Piaw Teo, Kim-Chuan Toh

Due to recent development in E commerce, there is a significant increase in cargo traffic at airports whose primary target is to serve passengers. To satisfy this demand, a new type of airpoint that only serves airplanes for cargo transportation has been built in China. In a typical business day of such airport, scheduled airplanes land at airport, stay and exchange cargo, finally leave at scheduled time. As a central planner of such airport, we study stands assignment problem in this setting, and our goal is to improve efficiency of cargo transportation during the stay of airplanes.

3 - Optimal Energy Trading with Capacitated Storage Asset in a Trading Hub

Qinghe Sun, National University of Singapore, Singapore, Singapore, qinghe_sun@u.nus.edu, Mabel Chou

The purpose of this paper is to develop a general merchant energy trading model for a hub accessible to multiple trading markets in which trading decisions can be analyzed and optimized. We introduce a multi-period warehouse problem under three types of constraints: storage space constraint, injection/withdrawal capacity constraints, and market-specific constraints. We formulate the problem a Markov decision process with uncertain spot prices, study the interplays among three types of constraints, and characterize the optimal trading policy under different scenarios. Finally, we present a computational example for a Liquified Natural Gas (LNG) hub and provide some managerial insights.

4 - Sparse and Efficient Rebalancing Operations: Concentrating the Flows in Dynamic Network

Jinjia Huang, Institute of Operations Research and Analytics, National University of Singapore, Singapore, Singapore, oraahj@nus.edu.sg, Mabel C. Chou, Chung-Piaw Teo, Linfeng Li

Motivated by the Bike Angels Program in New York's Citi Bike system, we study the use of volunteers as an alternative to rebalance bikes in a bike sharing system before peak hours. We discuss how a static network structure can be constructed to be used as the backbone to support the dynamic rebalancing operations, along with a simple algorithm to dispatch the volunteers in a real-time fashion. Depending on the operating conditions, our method produces a sparse structure that outperforms the long chains or recovers the fixed pick-up/drop-off structure used in the early days of the Bike Angels Program. We also verify the effectiveness of our method through a dataset from the Boston Hubway system .

■ TA17

CC- Room 305

Learning, Persuasion and Service Management

Sponsored: Manufacturing & Service Oper. Mgmt/Service Operations

Sponsored Session

Chair: Ramandeep Randhawa, University of Southern California, Los Angeles, CA, 90089, United States

Co-Chair: Achal Bassamboo, Northwestern University, Evanston, IL, 60208, United States

1 - Managing Customer Churn via Service Mode Control

Jiaqi Lu, Columbia University, c/o Clara Magram, New York, NY, 10027, United States, Yash Kanoria, Ilan Lobel

We consider the problem faced by an investment manager who makes decisions overtime between a risky asset and a safe asset. Meanwhile, the customer is unsophisticated and his probability of churn depends on how satisfied he is with recent rewards. We show that either myopic or a sandwich policy maximizes CLV. The latter uses the inferior of the two arms for intermediate happiness levels. Specifically, the firm becomes risk averse when the customer is marginally satisfied and risk seeking when the customer is marginally unsatisfied. We show that our results are robust to several important idiosyncrasies for the investment manager setting.

2 - When is Society Susceptible to Manipulation?

Mohamed Mostagir, University of Michigan, Ann Arbor, MI, 48109, United States, Asuman Ozdaglar, James Siderius

We study the classic social learning problem where agents try to uncover a state of the world (for e.g. whether a particular vaccine is safe, or whether burning fossil fuels leads to accelerated global warming) through their own experiences as well as what they learn from their friends. A principal (like a firm or a lobbying group) tampers with the learning process of the agents in order to steer them towards a particular action that might benefit the principal but is sub-optimal for the agents (for e.g. not to vaccinate even though the vaccine is safe). We examine under what conditions such manipulation is possible and describe how networks that are susceptible to manipulation can become more resilient.

3 - Persuading Risk-conscious Agents: A Geometric Approach

Krishnamurthy Iyer, University of Minnesota, Minneapolis, MN, 14850, United States, kriyer@umn.edu, Jerry Anunrojwong, David Lingenbrink

Motivated by practical concerns, we consider a bayesian persuasion problem between a principal and an agent where the agent may not be an expected-utility maximizer. In particular, the agent's utility may be non-linear in her belief; we deem such agents as risk-conscious. In such settings, revelation-principle fails to characterize of the set of signals needed in the optimal signaling scheme. Using results from convex analysis, we bound the number of signals needed, and reduce the sender's problem to solving a convex optimization program. We illustrate our results in the setting of signaling in an unobservable queue with customers whose utilities depend on the variance of their waiting times.

4 - Persuading Customers to Buy Early: Value of Personalized Information Provisioning

Ramandeep Randhawa, USC, Los Angeles, CA, United States, ramandeep.randhawa@marshall.usc.edu, Shobhit Jain, Kimon Drakopoulos

We study a pricing and information provisioning game between a better informed seller (such as a retailer) and its customers. The seller is (ex-post) better informed about product availability and can choose how to communicate this information to the customers. Using a Bayesian persuasion framework, we find that public information provisioning in which the firm sends the same information to all customers has limited value. However, personalized information provisioning, in which the firm can share different information with different customers, has significant value and has attributes very similar to personalized pricing.

■ TA18

CC- Room 306

Demand Analytics in Retailing

Sponsored: Manufacturing & Service Oper. Mgmt/Supply Chain

Sponsored Session

Chair: Aditya Jain, Baruch College, Zicklin School of Business, New York, NY, 10010, United States

1 - Estimating Demand in the Absence of Sales and Inventory Information

Sripad K. Devalkar, Assistant Professor, Indian School of Business, Ac3 L1 Room 3114, Hyderabad, 500032, India, sripad_devalkar@isb.edu, Sarang Deo, Aditya Jain, Naireet Ghosh

The retail sector in emerging economies is dominated by unorganized retail stores. These stores are characterized by a lack of formal inventory management and data capturing systems, and suppliers often lack visibility into retailer sales and inventory information. The lack of reliable information on retail store level sales and inventory presents interesting challenges for the supplier to estimate demand and plan replenishment decisions. We develop a demand estimation methodology built on the Expectation-Maximization algorithm using data on replenishments to the stores, often the only information available to the supplier.

2 - Robust Demand Estimation with Customer Choice Based Models for Sales Transaction Data

Sanghoon Cho, University of South Carolina, 413 Hawkeye Ct, Columbia, SC, 29206, United States, Mark Ferguson, Jongho Im, Pelin Pekgun

We propose a statistical procedure that can estimate the effect of product attributes and unobservable lost sales under a choice-based demand model using only historical sales transactions, product availability data, and market share information. Our proposed approach does not require time-homogeneous arrival rates, and allows for varying product attributes and choice sets over time. A set of simulation studies and an application to a real hotel dataset are conducted in comparison to several existing methods.

3 - Intertemporal Pricing under Customer Heterogeneity via Nonparametric Estimation

Hansheng Jiang, University of California Berkeley, Berkeley, CA, 94706, United States, hansheng_jiang@berkeley.edu, Junyu Cao, Zuo-Jun Max Shen

We study an intertemporal pricing problem for a group of products under unknown customer heterogeneity. Customers make choices according to a random coefficient multinomial logit (RCMNL) model that contains product features including price. We provide a highly scalable algorithm for estimating the distribution of customer's preference from observed sales data. We then study an intertemporal pricing optimization problem for heterogenoeous customers. Our data-driven approach integrates the customer segmentation and the pricing strategy. We illustrate the effectiveness of our method through both the synthetic and real data.

4 - Demand Estimation Error Caused by Latent Backorder

Sheng Zhao, National University of Singapore, Singapore, Singapore, zhaosheng@u.nus.edu

In a market where products face frequent stock out, demand estimation is extremely difficult due to censored data. A common practice is to take account the time when stock out occurs to estimate the demand. However, such estimation could be inflated due to consumer's backorder behavior. We propose a queuing model to address this issue, and characterize several properties that can explain the counter-intuitive phenomena in the market, using fluid approximation. We also conduct numerical experiments to test our findings, and conclude that our model provides considerable improvement to the performance.

■ TA19

CC- Room 307

Omnichannel Supply Chain

Sponsored: Manufacturing & Service Oper. Mgmt/Supply Chain

Sponsored Session

Chair: Jia Guo, The University of Alabama, Tuscaloosa, AL, 35401, United States

Co-Chair: Burcu B Keskin, University of Alabama, Tuscaloosa, AL, 35406, United States

1 - Choosing a Dual-channel Strategy: An Analytical Model with Pricing and Return Policy Decisions

Armagan Ozbilge, McMaster University, Hamilton, ON, Canada, ozbilgea@mcmaster.ca, Elkafi Hassini, Mahmut Parlar

Due to the proliferation of e-commerce, many traditional "bricks-and-mortar" retailers established an online channel and have become "bricks-and-clicks." This has presented retailers with the opportunity of operating different channel structures and at the same time the challenge of selecting and operating the right channel strategy. In this study we develop a stylized model where a dual-channel retailer selling a single product through an online channel as well as a physical store wants to determine the best pricing and return policy mix strategy.

2 - Supply Chain Design and Operations under Omni-channel Environment

Jia Guo, the University of Alabama, Tuscaloosa, AL, 35401, United States, jguo23@crimson.ua.edu, Burcu B. Keskin

We focus on supply chain design and omnichannel strategies with demand segmentation, cost structure, and more importantly, the company's operation ability. We formulate our problem as a two-stage stochastic programming model and use first-order optimality conditions to study the optimal inventory replenishment decisions. The omnichannel strategy decisions are made by analyzing the expected profit. We show that omnichannel strategies are not necessarily profitable for all retailers. Poor execution ability may result in losing the inventory pooling benefits when running omnichannel strategies.

3 - Crowdsourced Delivery: State-of-the-art, with Applications to Omnichannel Supply Chains

James Bookbinder, University of Waterloo, Toronto, ON, Canada, Aliaa Alnaggar, Fatma Gzara, Aliaa Alnaggar

Crowdsourced delivery is a new last-mile transportation solution adopted by many supply chains. We analyze its current industry status and provide a taxonomy of available platforms based on their matching mechanisms, target markets and compensation schemes. We review the OR literature addressing this topic and assess the realism of its assumptions in real-world problems. We highlight the application of crowdsourced delivery in omnichannel supply chains and identify key elements that distinguish it from classical transportation systems, to ultimately shed light on promising research directions.

■ TA20

CC- Room 308

Fun Ways of Introducing Business Analytics

Sponsored: Education

Sponsored Session

Chair: Jimmy Chen, Bucknell University

1 - Introduction to Probability: Bison Hold'em Poker Game

Jimmy Chen, Assistant Professor, Bucknell University, 95 Sunnyside Dr., Lewisburg, PA, 17837, United States, cmc052@bucknell.edu

Probability literacy is the foundation of business analytics. This study presents an interactive pedagogical game that aims to help students' learning of probability. Primarily designed for undergraduate students in business analytics courses, our game follows classic Texas Hold'em poker and is developed with Visual Basic Applications to function in most commonly available Microsoft Excel. Regardless of their prior exposure to Texas Hold'em poker, students can easily play along as every game rule is code-enforced. Through answering quiz questions embedded in the gameplay, our goal is to introduce the basics of probability to the students in a fun and immersive way.

2 - Lessons Learned Teaching a Case-Based Business Analytics Class

Eric Logan Huggins, Fort Lewis College, Durango, CO, 81301, United States, huggins_e@fortlewis.edu

One of the key lessons I have learned from teaching multiple sections of a case-based introductory business analytics course is that the more students are engaged - i.e., the class is "fun" - the more they tend to learn. So what are the best practices to engage students in this class? I will discuss the trade-off between open-ended versus well-defined assignments, how real data makes a difference, the triumphs and perils of group work and how I try to indoctrinate analytics as an ethos.

3 - Teaching Analytics Through Non-traditional Sports

Keith A. Willoughby, University of Saskatchewan, Department of Finance and Mangement Science, Saskatoon, SK, S7N 5A7, Canada, willoughby@edwards.usask.ca

Regrettably, many of our students approach quantitative courses with emotions ranging from fear to loathing. The deployment of sports examples may help students gain an enhanced appreciation for the value of analytical methods in understanding, exploring and helping to solve actual problems. We present a series of opportunities to illustrate important analytical concepts through the investigation of key problems in non-traditional sports. Our experience asserts the positive impact afforded by sports examples in the classroom, even if such sports may not be particularly well-known.

4 - Using Games in the Classroom to Shorten the Analytics Learning Curve

Kathryn Wilson Ernstberger, Professor of Decision Sciences, Indiana University Southeast, New Albany, IN, 47150, United States, kernst@ius.edu, Munirpallam A. Venkataramanan

Numerous methods for using games to introduce students to predictive and prescriptive analytics techniques are discussed and some are demonstrated. Engaging students first in a familiar and fun manner provides a natural and less intimidating transition to more complex business scenarios. The authors will discuss their experiences with these approaches in their analytics classes.

■ TA21

CC- Room 309

Innovations in Financing

Sponsored: Manufacturing & Service Oper. Mgmt/iFORM

Sponsored Session

Chair: Jiri Chod, Boston College, Chestnut Hill, MA, 02467, United States

1 - Consumer Privacy and Platform Design via Personalized Pricing and Ranking

Xiaoyu Wang, Washington University in St. Louis, St. Louis, MO, 63144, United States, xiaoyuwang@wustl.edu, Fuqiang Zhang

We propose a model of platform operations design via personalized pricing and ranking, and examine the impact of consumer privacy and information externality on the platform's profit and reputation.

2 - Platform Tokenomics

Nikolaos Trichakis, MIT, Cambridge, MA, 02143, United States, Jiri Chod, S. Alex Yang

We study two alternative business models of financing, building, and operating a platform that matches buyer and sellers in a multi-period setting and in the presence of moral hazard. In the traditional model, an entrepreneur raises capital by issuing equity, and makes money only by charging fees to platform users. In the blockchain-based business model, the entrepreneur raises capital and makes money by issuing cryptocurrency to be used on the platform, over which she relinquishes authority. We show that the latter model is preferable if (i) building the platform requires significant entrepreneurial effort and (ii) joining the platform by a user requires a significant irreversible investment.

3 - Contingent Stimulus in Crowdfunding

Longyuan Du, University of San Francisco, San Francisco, CA, United States, ldu5@usfca.edu, Ming Hu, Jiahua Wu

We study a model where backers arrive sequentially at a crowdfunding project. We characterize the dynamics of the pledging process. To boost success, we propose and characterize contingent stimulus policies including feature upgrade and limited-time offer. We show that the benefit of contingent policies is greatest in the middle of crowdfunding campaigns. Testing with the Kickstarter data, we demonstrate the benefit of the stimulus policies and highlight the importance of the timings to use those policies.

4 - Values of Traceability in Supply Chains

Yao Cui, Cornell University, Ithaca, NY, 14853, United States, yao.cui@cornell.edu, Ming Hu, Jingchen Liu

Recent technology development (e.g., Blockchain) has enabled end-to-end traceability of supply chains. When product failure occurs, such traceability information can be used to identify which supplier is at fault. This could revolutionize supply chain operations for industries where traceability is difficult to achieve under traditional technologies (e.g., agri-food and pharmaceutical). In this paper, we investigate the value of traceability under two different supply chain structures: 1) parallel supply chains, where all suppliers belong to the same tier of the supply chain, and 2) serial supply chains, where each supplier belongs to a different tier of the supply chain.

■ TA22

CC- Room 310

Research on Electric Vehicles and Energy Systems

Sponsored: Manufacturing & Service Oper. Mgmt/Sustainable Operations

Sponsored Session

Chair: Owen Wu, Indiana University, Bloomington, IN, 47405, United States

Co-Chair: Safak Yucel, Georgetown University, Washington, DC, 20057, United States

1 - Shared Autonomous Electric Vehicles for Strengthening Future Urban Microgrids

Wei Qi, Assistant Professor, McGill University, Montreal, QC, H3A 1G5, Canada, wei.qi@mcgill.ca, Mengyi Sha, Shanling Li

We envision the prospect where shared autonomous electric vehicles (SAEVs) will reinforce future urban electricity infrastructure in the form of solar-powered micrograms. We integrate cross-disciplinary modelling of transport and power systems with optimization to investigate the potential of SAEVs for improving the self-sufficiency and resilience of urban microgrids. Our model prescribes optimal citywide SAEV fleet operations of ride-sharing, repositioning, charging and discharging amidst various urban heterogeneities. Our findings highlight the value of centralized dispachability of SAEVs.

2 - Joint Planning of Refueling Stations and Grid Reinforcement for Hydrogen Fuel-cell Vehicles

Long He, National University of Singapore, Singapore, 119245, Singapore, longhe@nus.edu.sg, Wei Qi, Hongcai Zhang

In this paper, we propose an approach to jointly planning hydrogen refueling stations and power grid reinforcement. Our model explicitly handles the interconnectedness between transportation and power distribution networks. Furthermore, it captures the complexities of drivers' vehicle choice behavior and renewable energy integration.

3 - On the Range Anxiety for Electric Vehicles: An Empirical Investigation

Sang Won Kim, Assistant Professor, The Chinese University of Hong Kong, Hong Kong, skim@cuhk.edu.hk, Ho-Yin Mak, Marcelo Olivares, Ying Rong

Electric vehicles are an important technology for curbing the carbon footprint of road transportation. Despite substantial government incentives, mass adoption has yet to happen in major auto markets. Among the major shortcomings of EVs on the market are limited driving range and long recharging time, creating psychological concerns to drivers called range anxiety and making them reluctant to adopt EVs. Although the range anxiety is quite well-recognized, it has not been adequately quantified, quite possibly due to the lack of quality data. In this work, we propose a novel way to quantify the drivers' range anxiety on EVs by use of a dataset from a car sharing platform.

4 - Smart Charging of Electric Vehicles

Owen Wu, Indiana University, Kelley School of Business, Bloomington, IN, 47405, United States, owenwu@indiana.edu, Safak Yucel, Helen Zhou

Electrical vehicles increasingly penetrate the electrical grid, while the common practice at most charging stations is to charge EVs at the maximum possible speed. In this talk, we aim to look for the optimal pricing policy of a charging station that incentivizes customers to choose the 'right' parking time period to allow time-varying speed charging. By properly designing the pricing policy, we can incentivize customers with different time-sensitivity to pick up their vehicles at different times, reducing the charging cost and associated emissions.

5 - Pricing and Charging Time Policies for Electric Vehicles under Congestion

Chen-An Lin, Duke University, 100 Fuqua Drive, Durham City, NC, 27708, United States, chen.an.lin@duke.edu, Kevin Shang, Peng Sun

This paper studies a joint pricing and charging time control problem for a fast charging station, where customers (electronic vehicle drivers) are price and wait time sensitive. The station owner announces a menu that indicates the total payment and charging time. Each arriving driver decides whether to join the queue, which affects the congestion level. We characterize the optimal policy, compare it with benchmark policies, and reveal insights on managing fast charging stations.

■ TA23

CC- Room 3A

Joint Session DAS/Practice Curated: Applications of Decision Analysis for Federal, State, Provincial, and Tribal Natural Resource Management II

Sponsored: Decision Analysis

Sponsored Session

Chair: Sarah Converse

1 - Using Decision Science to Develop Conservation Management Strategies for an Imperiled Amphibian

Katherine M. O'Donnell, US Geological Survey, Gainesville, FL, United States, kmodonnell@usgs.gov

In recovery planning for federally-threatened Frosted Flatwoods Salamanders (Ambystoma cingulatum), we used structured decision making to address uncertainty about the effectiveness of possible habitat restoration actions at one of two remaining strongholds for the species (St. Marks National Wildlife Refuge, FL). We used stochastic dynamic programming to identify optimal strategies that balance species persistence and management costs. We have implemented several conservation actions, and we continue to monitor the species and its habitat to improve our model. This approach has enabled us to carry out important management actions despite uncertainty inherent in these decisions.

2 - Using Structured Decision Making and Machine Learning to Adaptively Manage Invasive Annual Bromes in Grassland Habitats in the National Parks

Max Post van der Burg, USGS, Jamestown, ND, United States, maxpostvanderburg@usgs.gov, Heather Q. Baldwin, Amy Symstad

National Parks preserve and protect historical and ecological landscapes which are under threat from invasion of exotic annual brome grasses. Managing these species is difficult because of uncertainty about the effectiveness of control strategies. We present a management framework to guide park control decisions, while improving understanding of the effects of management actions. Our framework was built using a structured decision-making process for defining management objectives and a Bayesian network model for predicting optimal actions. We describe how parks are using the framework and how new data generated following management actions are used to update the model over time.

3 - Decision Analysis to Identify a Restoration Strategy for Chinook Salmon in California's Central Valley

Adam Duarte, Oregon State University, Corvallis, OR, United States, James T. Peterson

Chinook salmon are in severe decline in many of their native habitats, including tributaries in California's Central Valley. We used a decision theoretic approach to identify Chinook salmon conservation objectives and develop a decision model to identify optimal state-dependent policies while considering various possible restoration actions. Forward simulation suggested this strategy greatly improved future fish populations, but sensitivity analyses indicated that these predictions were strongly influenced by model uncertainties. Thus, we also discuss how monitoring data can be used to reduce uncertainties and improve future management decisions.

4 - Prioritizing Threat Management for Species Recovery

Tara Martin, University of British Columbia, Vancouver, BC, Canada

One million species are at risk of extinction. The identification of actions needed to recover and conserve species, and ensure effective governance to oversee action implementation, presents enormous challenges. Priority Threat Management (PTM) is a decision tool that prioritizes solutions to this global crisis by estimating the cost-effectiveness and complementarity of alternative management actions. It draws on expert judgement through a structured expert elicitation process to estimate the cost, benefit and feasibility of actions and governance. Application of PTM to date spans 4 continents and in each case produces a blueprint for cost-effective species recovery under global change.

■ TA24

CC- Room 3B

Joint Session MCDM/Practice Curated: Combining AI, Spatial and Decision Analysis in a Decision Support System to Change the World

Sponsored: Multiple Criteria Decision Making

Sponsored Session

Chair: Philip J Murphy, InfoHarvest Incorporated, Seattle, WA, 98125-2055, United States

1 - Overview of EMDS Workflows and How They Support Strategic and Tactical Decision Making

Keith M. Reynolds, Research forester, USDA Forest Service, Corvallis, OR, United States, kreynolds@fs.fed.us

EMDS is a general spatial decision support framework for environmental analysis and planning, built on the open source Microsoft Workflow Foundation. The system includes four core analytical engines that collectively support both strategic and tactical planning as well as scripting tools for data summarization, transformation, and statistical analysis. The talk will address both standard workflows that users can manually invoke through the main EMDS interface as well as customized workflows that users can design with a built-in workflow editor to automate complex workflow task sequences.

2 - What Regional Land Managers and Planners Needs from an SDS in the Face of Climate Change and Population Growth

Phillip North, The Tulalip Tribes, WA, United States

Protecting functioning habitats and restoring degraded habitats are critical actions for salmon and Puget Sound recovery. Restoration alone cannot keep up with habitat loss and water quality degradation from development and the pressures of anticipated population growth and climate changes. We need a framework for prioritizing diverse projects and programs that takes into account the complexity of the science, competing stakeholder goals, treaty obligations, and the need for regulatory harmonization. Such a framework is at the heart of the Tulalip Tribes Harmonization project.

3 - Changing the World Requires Funded Action – Creating Programs of Funded Projects

Bill Levings, WHLevings, Seattle, WA, 98125, United States

Improving infrastructure or ecosystems requires generating sets of projects that deliver benefit and can be funded within budgetary constraints. Such programs of projects need to be understood and supported both by the communities where the projects will be sited and the larger community that will be funding them. We demonstrate an integrated process to prioritize proposed projects based on their spatial attributes and how well they support social, ecological and economic objectives. Based on multiple funding sources, a program of projects is generated. We describe how the map interface can communicate important information about these programs to decision makers and effected communities.

4 - Combining Rules-based Expert System to Support Permit Regulations for Ecosystem Management

Philip J. Murphy, InfoHarvest Incorporated, Seattle, WA, 98125-2055, United States, Philip.Murphy@InfoHarvest.Com

Federal agencies, states, and counties develop regulations that require permit approval for new projects that will significantly affect the landscape. For land owners, this presents the challenge of how to find which permits are likely required for a specific type of projects in a specific place on the land scape. Based on the governing regulations, they will need to understand the proximity of the project site to wetland, navigable waters, etc. We will show how the VisiRule rules-based experts system combined with a spatial information system can provide a sustainable solution for both the general public and permit reviewers to use to identify all permits per project or for all projects in an area.

■ TA25

CC- Room 401

Addressing Human Trafficking and Societal Issues through OR and Analytics

Emerging Topic: Humanitarian and NotforProfit Operations

Emerging Topic Session

Chair: Renata Alexandra Konrad, Worcester Polytechnic Institute, Worcester, MA, 01609, United States

1 - Human Trafficking Transit Monitoring in Nepal: A Data Analytics Case Study

Geri Dimas, Worcester Polytechnic Institute, Worcester, MA, United States, gldimas@wpi.edu, Renata Alexandra Konrad, Kayse Lee Maass, Andrew C. Trapp

Like many data involving vulnerable people, human trafficking (HT) data are fragmented and disparate. Understanding individuals vulnerable to HT is an important step in elucidating the underlying structure of these illicit networks. We explore six years of transit monitoring survey data from an anti-HT operation in Nepal, discuss insights gleaned, and introduce a data envelopment analysis model to increase the effectiveness of identifying HT in a resource constrained environment. We conclude by discussing lessons learned and the importance of data structure and domain expertise.

2 - A Review of Questions Driving Analytic Approaches to Ending Sex Trafficking of Children in the United States

Kendra Taylor, KEYFFICIENCIES, Atlanta, GA, 30308, United States, kendra@keyfficiencies.com

We look at the pressing questions to which analytics has provided answers or insight regarding sex trafficking and exploitation of children in the United States. We also look at the unanswered questions to which analytics can provide answers or insight. This approach begins with policy and economic motivators to maximize the utility of the analytics results.

3 - Disrupting Exploitation and Trafficking Labor Supply Networks in Post-Harvey Rebuild

Matt Kammer-Kerwick, The University of Texas at Austin, Austin, TX, 78723, United States, mattkk@ic2.utexas.edu, Yanling Chang

Construction is one of the largest industrial sectors in the global economy as it accounts for about 11 percent of global GDP. The sector is characterized by low barriers of entry, low-wages, hazardous work (the International Labor Office defines construction as one of the most hazardous sectors for workers), and a disproportionate share of migrant workers. The project aims to provide an improved understanding of the states of exploitation and trafficking that can occur among day laborers working in the chaotic environment that accompanies recovery and rebuild efforts after a natural disaster. Specifically, the project involves three major activities: 1) Conducting qualitative case studies to explore quantitative parameterization of the problem space. 2) Exploring multi-agent, game theoretic decision support frameworks as an initial attempt to rigorously model human trafficking. 3) Providing managerial insights to policy makers, regulators, and companies on how to monitor, combat, and disrupt exploitation and labor trafficking with limited resources. The modeling frameworks being developed address the partial observability of laborers as well as the intelligent and adaptive behavior of both laborers and those who exploit them. This presentation reviews findings from fieldwork and preliminary modeling approaches as part of the first year of a two year project.

4 - Improving Community Paramedicine via Data Driven Optimization: Selective, Proactive Treatment of Patients

Shima Azizi, Worcester Polytechnic Institute, Worcester, MA, 01609, United States, Andrew C. Trapp, Sharon Johnson, Renata Konrad, Brenton Faber

Community paramedicine is a recent healthcare innovation that enables proactive visitation of patients at home, often shortly after Emergency Department and hospital discharge. We propose to reduce both hospital costs and readmissions, and increase patient welfare. We develop an integer program that selects patients and routes healthcare providers to maximize overall patient welfare, while prioritizing shorter tours. We discuss our computational experiments on a variety of test instances inspired by real, deidentified data from a rural hospital system, which solve in reasonable runtimes.

■ TA26

CC- Room 4C-1

Joint Session Serv Sci/Practice Curated: AI in Service Science

Joint Session

1 - Early Detection of the Replicability of Scientific Findings Using Human and Machine Intelligence

Yang Yang, Kellogg School of Management, Evanston, IL, United States, yang.yang@kellogg.northwestern.edu, Youyou Wu, Uzzi Brian

Using 413 studies from 80 journals that underwent rigorous manual replication, we test the ability of artificial intelligence to address the replication problem in science. We calibrate our model using 96 studies and tested it on 317 diverse studies that span disciplines, methods, and topics. We find that our model predicts replicability better than statistics (i.e., p-value) and individual reviewers and as accurately as prediction markets. Further, tests indicate that our model does not show biases common to human. Finally, we discuss how AI can address replication problems at scale in ways that current methods cannot and can advance research by combining human and machine intelligence.

2 - Closing the Gap Between AI Methods and Better Decisions

James Williams, Sr. Principal Consultant, FICO Xpress, Roseville, MN, United States, JWilliams@fico.com

With no shortage of capable predictive methods available to analytics professionals, why do so many organizations struggle converting all of that power to actually enable better business decisions? The answer may depend on the lens taken by project teams. This talk will center on putting the end game of better decisions in primary focus, aligning all efforts (data, methods and yes, even user adoption psychology) with that goal.

3 - Predicting the Most Useful Online Reviews Using Advanced Latent Topic Features

Eunjung Lee, University of Wisconsin-Milwaukee, Brookfield, WI, United States, lee482@uwm.edu

With the enormous growing amount of online reviews in websites, diverse methods to identify the most helpful reviews have been studied actively by many researchers. However, most previous studies tried to find helpful reviews without considering entities of business or products. “A” review can be considered as the most helpful review for “B” product, but not for “C” product. In this research, we aim to predict the best five reviews for each business entity. Furthermore, to improve the precision of the prediction, we developed advanced features by analyzing latent topics of online reviews. This research successfully shows that our suggested model predicts the best reviews better than existing approach.

4 - Emotional Response of the Public to the Development of Artificial Intelligence—Sentiment Analysis Based on Microblog Text

Ma Liyi, Beijing Union University, Beijing, China, maryliyi@126.com, He Qin

The existing studies on the impact of technological progress on employment effect mainly focus on phenomenal description, detail analysis and trend prediction, and there is no research that can accurately quantify the impact of the development of artificial intelligence (AI) on the public sentiment. Based on social media, this study builds a sentiment analysis model based on support vector machine using machine learning, sentiment analysis and other related methods, and carries out a quantitative evaluation on the psychological impact of artificial intelligence on the public, and finally verifies the effectiveness of this model.

■ TA27

CC- Room 4C-2

Decision Making and Data Driven Decision Models in Service Industry

Sponsored: Service Science

Sponsored Session

Chair: Y. Ilker Topcu, ITU, Turkey

Co-Chair: Sezi Cevik Onar

1 - Revisiting the Decision Support Model for Prioritizing Critical Road Structures of Istanbul

Ozay Ozaydin, Dogus University, Istanbul, 34722, Turkey, oozaydin@dogus.edu.tr

A decade has passed since the last study on evaluating the critical road structures of Istanbul. Since then, the road network has significantly changed. To determine the important network elements, a model with four main criteria was developed with decision makers from the Istanbul Metropolitan Municipality. The same decision support model has been revisited, and the data is updated. The total number of road network elements have increased, but the number of critical structures has decreased. A comparative analysis is also conducted to visualize the effects of urbanization on emergency management.

2 - Analyzing Relationship Between Human Development and Competitiveness Using DEA and Cluster Analysis

Ozgur Kabak, Associate Professor, Istanbul Technical University, Istanbul, 34367, Turkey, kabak@itu.edu.tr, Hakan Kılıc

This study analyses the bilateral relations between human development (HD) and competitiveness (COM). Data Envelopment Analysis (DEA) with windows is used to calculate efficiencies of countries on converting their HD to COM and COM to HD. Stepwise cluster analysis for time periods is used to analyze the results of the DEA models. 56 countries are evaluated for the years 2010-2017 based on the data of the Global Competitiveness Index and Human Development Index. We find that the competitiveness of a country has a positive impact on its human development with a three-year time lag. Furthermore, we ranked the countries based on their human development and competitiveness levels.

3 - Stochastic Location Allocation Model for Mobile Blood Facilities

Ilker Topcu, Istanbul Technical University, Isletme Fakulte, Istanbul, 34367, Turkey, Gul Imamoglu

Blood supply can only be provided by voluntary donors. To provide this supply, it is necessary to create the opportunity of blood donation at points where there are plenty of people. For this reason, besides local blood centers, mobile blood facilities, which are easy to access by donors and cost effective facilities, are established. Since these mobile facilities only capable of blood collection and not capable of processes such as centrifugation, collected blood should be taken to the local blood centers within a limited time. The aim of this study is to construct a two stage multi period stochastic location-allocation model for blood collection to minimize overall cost while demand is met.

4 - Stochastic Location Allocation Model for Mobile Blood Facilities

Gul Imamoglu, Istanbul Technical University, Turkey, Ilker Topcu

Blood supply can only be provided by voluntary donors. To provide this supply, it is necessary to create the opportunity of blood donation at points where there are plenty of people. For this reason, besides local blood centers, mobile blood facilities, which are easy to access by donors and cost effective facilities, are established. Since these mobile facilities only capable of blood collection and not capable of processes such as centrifugation, collected blood should be taken to the local blood centers within a limited time. The aim of this study is to construct a two stage multi period stochastic location-allocation model for blood collection to minimize overall cost while demand is met.

■ TA28

CC- Room 4C-3

Smart Service Systems: Humans & Artificial Intelligence

Sponsored: Service Science

Sponsored Session

Chair: Ralph D. Badinelli, Virginia Polytechnic Institute, Blacksburg, VA, 24061, United States

Co-Chair: Haluk Demirkan, University of Washington, Tacoma, University of Washington, Tacoma, Tacoma, WA, United States

1 - An Empirical Analysis of the Effect of Mismatched App and OS Versions on Consumer Purchase

Luna Zhang, Assistant Professor, University of Washington Tacoma, Tacoma, WA, United States, xyzhang5@uw.edu, Ruomeng Cui, Yuliang Yao

The proliferation of mobile devices and mobile networks makes the mobile commerce an increasingly important yet understudied research topic. Using a large dataset from an online retailer, we empirically examine the adoption of mobile operation system (OS) and mobile application (app) on consumer purchase. We find that consumers with a newer app version are more likely to make a purchase than those with an older app version. A further investigation reveals that a mismatch between mobile OS version and app version can increase consumer probability of purchase. We attribute this result to the reduced consumer shopping pace.

2 - The Role of Emotion in Human Decision Making: Impacts on Agents and AI

Margo Bergman, University of Washington Tacoma, Tacoma, WA, United States, mwb4@uw.edu

Agent-based modeling, by necessity, involves modeling real-world human decisions that contain factors such as emotion, thought, and habit are difficult or impossible to observe, however, should be included in models to improve our understanding of people and systems. Research in agent-based modeling has questioned whether computational agents, if they are to mimic human decisions, must be able to include the emotional component of decision making in their algorithms. This paper will present a brief survey of theories of emotion in human decision making; analyze the literature of, and make recommendations for, integrating models of emotion into the decision making of agents.

3 - Value Co-creation and Out-tasking with Smart Analytics and Artificial Intelligence

Haluk Demirkan, Professor, University of Washington Tacoma, Tacoma, WA, United States, haluk@uw.edu

There is no doubt that computers are increasingly capable of doing things that humans could once do exclusively. Smart machines are gaining human capabilities, such as recognizing voices, processing natural language, and interacting and learning with the physical world through vision, smell, touch, mobility and motor control. In some cases, these machines do a much faster and better job than people at recognizing patterns, performing rule-based analysis from very large amounts of data, and solving structured and unstructured problems. We will discuss how we can utilize these smart machines as tools, assistants, collaborators and coach to work effectively with smart machines.

4 - Principles of Emergence of Co-creation from Service Ecostructures

Ralph D. Badinelli, Virginia Polytechnic Institute, Dept of Business Information Tech (0235), Blacksburg, VA, 24061, United States, ralphb@vt.edu

Motivated by the proliferation of new service ecostructures enabled by Internet of Things (IoT), Big Data Analytics (BDA) and Artificial Intelligence (AI), this paper derives principles for the design of viable, smart service systems and predictions of their performance. Engagement decisions of service participants are mediated by these technologies in ways that can be beneficial and detrimental. Principles of system design are derived from theoretical constructs of transformation functions, decision analysis, service ecostructure, Normalized Systems Theory (NST) and Viable Systems Approach (VSA). The paper presents simulations of service trajectories to illustrate these principles.

■ TA29

CC- Room 4C-4

Joint Session AMD/Practice Curated: Economics of Auctions and Market Design

Sponsored: Auction and Market Design

Sponsored Session

Chair: Robert Day, University of Connecticut, Storrs, CT, 06269-1041, United States

1 - Procuring Lemons

Giuseppe Lopomo, Duke University, FSB, Durham, NC, 27708, United States

When the quality of a good or service is non-contractible, a procurement agency faces a ``lemons” problem. In a model where each supplier is privately informed about both the quality of its product and its production cost, we show that the buyer’s expected surplus is maximized by a ``low-bid-lottery” auction (LoBLA). In this auction, if some bidders bid below a ``target price”, each of these bidders sells the good at the target price with the same probability; and if all bidders bid above the target price, the lowest bidder supplies the good and is paid the second lowest bid.Expected gains from trade are also maximized, subject to incentive constraints, by a LoBLA with a higher target price.

2 - Optimization and Analytics at the Federal Communication Commission

Karla L. Hoffman, Professor, George Mason University, System Eng and Operations Research Dept, Fairfax, VA, 22030, United States, khoffman@gmu.edu, Brian B. Smith, Tony Coudert, Rudy Sultana, Yasser Nadeem

We present the current work of the optimization team at the FCC. We detail the current state of the television transition following the Broadcast Incentive Auction and describe the constant coordination that is allowing more than 1000 television stations to move to their new channels assignments. In addition, we will present the optimization models developed for the upcoming combined auction of 37, 39, and 47 GHz spectrum for 5G (known as Auction 103). Optimization is used to reconfigure existing licenses in a manner that allows the auctioning-off of 3400 MHz of high-frequency spectrum nationwide.

3 - Robust Bidding in First-price Auctions: How to Bid Without Knowing What Others Are Doing

Bernhard Kasberger, University of Oxford, High Street, Oxford, OX14AW, United Kingdom, Karl Schlag

We show how to bid in first-price auctions when a bidder knows her own value but not precisely how others will bid. To do this we introduce a novel and general method for how to make choices in strategic settings without assuming common knowledge or equilibrium behavior. Accordingly, we first eliminate environments that are believed not to occur and then find a robust rule that performs well in the remaining environments. We test our bid recommendations using data from laboratory experiments and from the field. We find that our bids outperform those actually made by the real bidders.

4 - The Menu-Size of Approximately Optimal Auctions

Yannai A. Gonczarowski, Postdoctoral Fellow, Microsoft Research, Cambridge, MA, United States, yannai@gonch.name

We consider a monopolist who wishes to sell n goods to a single additive buyer whose valuations for the goods are drawn from independent distributions. The question of the possibility of extracting an arbitrarily high fraction of the optimal revenue via a finite menu size remained open since the seminal paper of Hart and Nisan (2013), and so has the question of any lower bound on the menu size that suffices for extracting an arbitrarily high fraction of the optimal revenue when selling a fixed number of goods, even for two goods and even for i.i.d. bounded distributions. In this talk, we resolve both of these questions. Based upon Babaioff, Gonczarowski and Nisan (STOC 2017); and Gonczarowski (STOC 2018).

■ TA29a

CC- Room 400

Congestion Models and Satisfaction: Models and Transparency

Sponsored: Manufacturing & Service Oper. Mgmt/Service Operations

Sponsored Session

Chair: Laurens G. Debo, Dartmouth College, Hanover, NH, 03755, United States

Co-Chair: Robert Shumsky, Dartmouth College, Hanover, NH, 03755, United States

1 - Capacity Planning with a Blended Workforce

Jing Dong, Columbia University, Uris Hall 413, 3022 Broadway, New York, NY, 60208, United States, Rouba Ibrahim

We study cost-minimizing staffing decisions in service systems where the manager must decide on how many flexible (contractors) and/or fixed (full-time) agents to staff in order to effectively balance operating costs, varying customer demand patterns, and supply-side uncertainty, while not compromising on the quality of service offered to customers. We derive the optimal staffing policy and glean insights into the appropriateness of alternative workforce models. We also shed light on the distinction between demand- side and supply-side uncertainties in queueing systems.

2 - Operational Transparency: Showing When Work Gets Done

Robert Louis Bray, Kellogg School of Management, Northwestern University, Evanston, IL, 60202, United States, r-bray@kellogg.northwestern.edu

I study how customers respond to operational transparency with Alibaba logistics data. The sample describes 4.68 million deliveries. Each delivery has between four and ten track-package activities, which customers can check in real time, and a delivery service score, which customers leave after receiving the package. I regress the delivery scores on the track-package-activity times. I show that customers punish early idleness less than late idleness, leaving higher delivery service scores when track-package activities cluster toward the end of the shipping horizon.

3 - Optimal Delay Information Design to Manage the Customer Waiting Experience

Sina Ansari, Tuck School of Business Dartmouth College, Hanover, NH, 03755, United States, sina.ansari@tuck.dartmouth.edu, Robert Shumsky, Laurens G. Debo

We study the optimal delay information design to a customer who has to wait for an uncertain amount of time for a service to start. We characteristic the optimal predictor taking into account (a) customers' aversion for delays in expected start time, as well as (b) their preference for more precise information while waiting. We show that the former informs customers about extreme events (either a very short or very long wait time, or, wait time around average), while the latter informs the customers about the expected wait (either a short or a long wait). We discuss implications for practice.

4 - Quoting Lead-times When Quotes Affect Customer Satisfaction

Riccardo Mogre, Durham University, Millhill Ln, Durham, DH1 3LB, United Kingdom, Tava Olsen, Valery Pavlov

We study a lead-time quotation problem for a manufacturing or service provider. We represent its processing system as a single-server queue. Based on recent empirical evidence, we explicitly model the effects of quotes and delays on customer satisfaction, which the provider takes into account when quoting lead-times.

■ TA30

CC- Room 6A

Tutorial: Data-driven Methods for Markov Decision Problems with Parameter Uncertainty

Emerging Topic: Tutorials

Emerging Topic Session

1 - Data-driven Methods for Markov Decision Problems with Parameter Uncertainty

Shie Mannor, Technion, Haifa, Israel, Huan Xu

In nearly every real sequential decision problem there is some uncertainty concerning the actual parameters of the decision problem. In this tutorial we survey different approaches to tackle the problem of finding an optimal, or at least a reasonable, policy when the parameters are not known in advance. Not knowing the parameters leads to two problems: first, the policy is not optimal and second the estimated return of the policy the decision maker chooses is typically overly optimistic. We advocate for using robust optimization to circumvent these effects and survey different approaches for different settings where the model is data-driven and hence some uncertainty in the parameters must be taken into account.

■ TA31

CC- Room 6B

Military and Civil Works Applications

Sponsored: Military and Security

Sponsored Session

Chair: Christina Rinaudo

Co-Chair: Randy K. Buchanan, USACE - ERDC, Vicksburg, MS, 39180, United States

1 - A Systems Engineering Approach for Sensor Integration and Placement

Randy K. Buchanan, USACE - ERDC, Vicksburg, MS, 39180, United States, Christina Rinaudo, James Richards, Mohammad Marufuzzaman

Agencies are challenged with developing measures to optimize emerging security sensing technology options to ensure area protection. A systems engineering integrated approach could provide insight into optimization resulting in increased effectiveness and lower costs. This presentation provides an overview of research efforts related to conducting a system of systems sensor simulation and placement assessment. The proposed final model could help in identifying courses of action for deployment of sensor suites for increasing the likelihood of recognizing and interdicting elements breaching a given area.

2 - Using Dredge Portfolio Optimization Methods to Improve Waterway Network Maintenance

Kayla A. Cotterman, Research Scientist, Engineer Research and Development Center, Vicksburg, MS, United States, kayla.a.cotterman@erdc.dren.mil, Drew A. Loney, Dustin T. Brown, K. Ned Mitchell

The U.S. Army Corps of Engineers (USACE) has developed two optimization tools to fulfill its mission to maintain safe and reliable transportation across ports and inland waterways. Dredge Project Selection allocates funding to projects given the disruption caused by channel shoaling and the interconnectivity of the waterway trade network. Dredge Scheduling organizes the public and private dredge fleets to maximize production and uptime given project environmental and dredge operating constraints. Within the two-year rolling budget cycle, these tools have a multi-year planning window creating a comprehensive strategy for the USACE dredging program.

3 - Assessing Computer-aided Models of Civil Structures Using an Immersive Virtual Collaboratory Experience

Michael Andre Hamilton, Mississippi State University, Vicksburg, MS, United States, michaelh@iser.msstate.edu, Parker Jones

The CAD-BIM Technology Center & MSU have been evaluating the use of VR to better evaluate CAD models during the verification and validation process. The goal is to minimize the number of unidentified issues during the modeling phase by providing a realistic virtual walkthrough to investigate problem areas. A test product was developed using VR to perform a walkthrough of the Wilkinson Pump Station CAD model. The system was built to accommodate multiple users from different physical locations collaborating to evaluate the models. The users are provided with virtual tape measures and the ability to write notes in the environment about items that require modifications, removals, or additions.

4 - Value Model and Metric Development to Support USACE Civil Works Portfolio Investment Decision Making

Christina Rinaudo, USACE Engineer Research and Development Center, Vicksburg, MS, 39180-6199, United States, christina.h.rinaudo@usace.army.mil, Kayla Cotterman

The US Army Corps of Engineers (USACE) Civil Works (CW) portfolio includes $250 billion worth of capital assets. As infrastructure ages and budgets decrease, new asset management strategies are required that support maintenance, repair, replacement (MR&R), and acquisition activities while also providing the greatest value to the USACE and to the Nation. This presentation provides an overview of research efforts related to analyzing value models and investigating relevant metrics in order to support the USACE-CW efforts towards generating defensible budgets that could bring high value to the USACE and to the Nation.

■ TA32

CC- Room 6C

Optimizing Supply Chains under Uncertainty

Sponsored: Optimization/Optimization Under Uncertainty

Sponsored Session

Chair: Eojin Han, Northwestern University, Evanston, IL, 60208, United States

Co-Chair: Omid Nohadani, Northwestern University, Evanston, IL, 60208-3119, United States

1 - Designing Interpretable Policies in Pharmacy Supply Chain

Eojin Han, Northwestern University, Evanston, IL, 60208, United States, eojinhan2020@u.northwestern.edu, Chaithanya Bandi, Omid Nohadani

We consider a two-stage inventory network problem where the demands at multiple locations are fulfilled from several warehouses. The decision maker needs to replenish inventories of the warehouses before observing demands, and the deliveries are made upon their realization. To address uncertainty in demand distribution, we model the problem as a two-stage distributionally robust optimization problem. We develop easy-to-interpret policies via dividing future uncertainties into finite subsets with contingency plans assigned for each piece. We show that an optimal partitioning structure can be constructed by "translated orthants", and discuss its tractable implementation.

2 - Statistical Bias in the Newsvendor Model

Michael R. Wagner, University of Washington, Foster School of Business, University of Washington, Seattle, WA, 98195, United States, mrwagner@uw.edu, Andrew Siegel

We consider the Newsvendor model where uncertain demand is assumed to follow a probabilistic distribution with known functional form, but unknown parameters. These parameters are estimated, unbiasedly and consistently, from data. We show that the classic maximized expected profit expression exhibits a positive systematic bias, where realized profits are overestimated. We provide an asymptotic adjustment so that the estimate of maximized expected profit is unbiased. Extensive numerical experiments confirm our theoretical results.

3 - Multisourcing under Dependent Supplies

Qi Feng, Professor, Purdue University, West Lafayette, IN, 47907, United States, annabellefeng@purdue.edu, Justin Jia, J. George Shanthikumar

Firms inevitably source from suppliers with dependent material flows, and such supply dependence, created by common second-tier suppliers or common economic environment, is often positive. By expanding the space of ordering decision to a class of contingency policies, we identify conditions under which the dynamic planning model has a concave transformation. Our analysis suggests that the firm may order more from a less reliable supplier than from a more reliable one who charges the same procurement cost.

■ TA33

CC- Room 602

Pyomo I

Sponsored: Optimization/Computational Optimization and Software

Sponsored Session

Chair: David Bernal Neira, Carnegie Mellon University, Pittsburgh, PA, 15232, United States

1 - Recent Developments in Pyomo

Bethany Nicholson, Sandia National Laboratories, Albuquerque, NM, United States, John Siirola

In this presentation we highlight some of the recent developments in the Pyomo project, including improved performance, improved expression management, new solver interfaces, and new optimization algorithms implemented natively in Pyomo.

2 - A Generalized Cutting Set Approach for Robust Process Design

Natalie M. Isenberg, Carnegie Mellon University, Dept of Chemical Engineering, Pittsburgh, PA, 15213, United States, nisenberg@cmu.edu, Paul Akula, Debangsu Bhattacharya, David C. Miller, Chrysanthos E. Gounaris

There is a breadth of literature studying robust optimization in the context of linear and convex models. However, chemical processes often possess complex nonlinearities and non-convexity due to physical and chemical state equations. In this work, we extend the robust cutting-set method, which sequentially hedges against realizations of parametric uncertainties, to identify risk-averse solutions to chemical process models. Our proposed method handles the case where a model consists of mostly state equations that cannot be readily simplified out of the formulation, and is also valid for models with nonlinearities and non-convexities in both the decision variables and uncertain parameters.

3 - Mixed Integer Nonlinear Decomposition Toolbox in Pyomo MindtPy

David Bernal Neira, Carnegie Mellon University, Pittsburgh, PA, 15232, United States, debernal@andrew.cmu.edu, Romeo Valentin, Qi Chen, Ignacio E. Grossmann

This work describes a software toolbox developed in Pyomo, a modeling and optimization application in Python, where decomposition methods for solving mixed-integer nonlinear programs (MINLP) are implemented. Decomposition methods for MINLP rely on the iterative solution of mixed-integer linear programs and nonlinear programming; which have had a steady and considerable improvement in the last years. Several decomposition methods, together with recent algorithmic improvements such as primal heuristics and level based methods, are available in MindtPy. We illustrate the application of this toolbox on a set of convex MINLP problems of varying sizes and degrees of difficulty.

4 - Shot – A Polyhedral Outer Approximation Based Solver for Convex MINLP

Jan Kronqvist, Dr, Imperial College London, London, 20500, United Kingdom, j.kronqvist@imperial.ac.uk, Andreas Lundell

The Supporting Hyperplane Optimization Toolkit (SHOT) is an open-source solver that has proven to be very efficient for solving convex mixed-integer nonlinear programming (MINLP) problems. SHOT combines lower bounding algorithms based on linear outer approximations of the feasible region together with several primal heuristics. The latest developments include improved non-convex capabilities and we are working on making SHOT available in Pyomo, and thus, expanding the options for solving MINLP in Pyomo.

■ TA34

CC- Room 603

Approaches to Business Applications of Data Mining and Risk Analysis Techniques

Sponsored: Data Mining

Sponsored Session

Chair: Paolo Catasti

1 - A From-Scratch, Data-Driven Approach to Teaching Simulation Modeling of Business Decisions.

Jeffrey W. Ohlmann, University of Iowa, Henry B. Tippie Coll of Bus Mgmt Sci, Iowa City, IA, 52242-1000, United States, jeffrey-ohlmann@uiowa.edu

We step through a pedagogical approach to integrating data analysis and mathematical modeling in a case-style problem starting "from scratch." A general problem context is proposed and then we progress in a Socratic method, guiding students through a formal problem statement, identification of the data required or desired to analyze the problem. Encouraging trial-and-error, the analysis then proceeds to data wrangling, using data to model uncertainty in a simulation model, construction of model logic, and assessment of model output.

2 - Teaching Factorization Machines to Deep Learning Architectures: Business Use Cases with Code Examples

Matthew A. Lanham, Purdue University, 112 Eastland Drive, Lafayette, IN, 47905, United States, lanhamm@purdue.edu

This talk explains and demonstrates with software some state-of-the-art predictive modeling approaches and how they are being used within business. The motivation for this talk is that advances in machine learning and AI continue to happen rapidly. Fortunately, many of these recent developments are available in either open-source libraries or commercial software, but you may not be sure where to start. The talk will be useful for those interested in data mining or business analytics that would like some business use cases and code examples that might one might use for teaching, adaptation and exploration to your own business problems, or scholars looking for a place to start experimenting.

3 - Predicting Bone Marrow Transplant Clinic Staffing Requirements from Historical Patient Data

R. Jerome Dixon, PhD Student, Integrative Life Sciences, Virginia Commonwealth University, Richmond, VA, 23284, United States, dixonrj@vcu.edu

Virginia Commonwealth University's Massey Cancer Center Bone Marrow Transplant Center requested an analysis of their historical patient data to forecast future staffing requirements. This analysis uses a myriad of machine learning and data visualization tools (SAS Enterprise Miner, Tableau, R/RStudio, and Excel) with System Dynamics to formulate a clinical staffing forecast model.

4 - An Approach to the Evaluation of Teaching Effectiveness at the School of Business Using a Combination of Data Mining Techniques.

Paolo Catasti, Virginia Commonwealth University, Richmond, VA, 23284, United States, pcatasti@vcu.edu, Evandro Moreno

We used a combination of multiple regression analysis and hierarchical clustering to develop a model that evaluates teaching effectiveness at the Virginia Commonwealth University School of Business by accounting for variables such as class size, evaluation completion rate, class mean GPA, class grade distribution, and course difficulty level. The model is first trained on 2,636 records of 3-credit hour classes across five academic years consisting of information received from anonymized course evaluations and confidential students' records; and then validated on two additional academic semesters. Finally, a metric that may help department chairs to evaluate instructors is proposed.

■ TA35

CC- Room 604

Integrated Methods in Optimization

Sponsored: Optimization/Integer and Discrete Optimization

Sponsored Session

Chair: Joris Kinable, Eindhoven University of Technology, Eindhoven, 5612 AR, Netherlands

1 - Exploiting Counterfactuals for Scalable Stochastic Optimization

Meinolf Sellmann, Lab Director, General Electric, Niskayuna, NY, United States, Kevin Tierney, Stefan Kuhlemann

We propose a new framework for decision making under uncertainty to overcome the main drawbacks of current technology: modeling complexity, scenario generation, and scaling limitations. We consider three optimization problems, Stochastic Knapsack, Stochastic Shortest Path, and Resource Scheduling with uncertain job durations, all with recourse. We illustrate how an integration of constraint optimization and machine learning technology can overcome the main practical shortcomings of the current stateof the art.

2 - On the Consistent Path Problem

David Bergman, University of Connecticut, Storrs, CT, United States, david.bergman@uconn.edu

In this talk we will discuss a new and promising decomposition approach to combinatorial optimization problem that are modeled through recursion. We will discuss several applications and present some ideas on how to efficiently optimize over such a decomposition.

3 - Computing Wasserstein Distances via GPU-accelerated Column Generation

Louis-Martin Rousseau, Professor, Ecole Polythechnique de Montreal, Montreal, QC, H3C 3A7, Canada, louis-martin.rousseau@polymtl.ca, Stefano Gualandi

This paper presents a GPU-accelerated Column Generation algorithm for the exact computation of Wasserstein distance between a pair of discrete measures. Currently,exact solvers can only solve instances of moderate size, because the fully dense cost matrix becomes too large to be stored in computer memory. We solve the master problem with a new implementation of the Network Simplex algorithm that support reoptimization, and and a efficient parallel algorithm that solves the pricing subproblems on a GPU. Numerical results on standard benchmarks show that our exact solver is competitive with current state-of-the-art exact approaches in terms of running time, while it can solve much larger problems.

4 - Learning Scheduling Models from Event Data

Arik Senderovich, University of Toronto, Toronto, ON, Canada, sariks@mie.utoronto.ca, Kyle Booth, Chris Beck

A significant challenge in scheduling is the creation of a parameterized model: the set of resources and their capacities and the types of activities and their temporal and resource requirements. In practice, such models are developed manually by skilled consultants and used repeatedly to solve new problem instances. In this work, we automate the creation of such models by learning them from data. We introduce a novel methodology that combines process mining, timed Petri nets (TPNs), and constraint programming (CP). To demonstrate the value of the approach we conduct experiments in which we learn and solve models using real-world data from an outpatient hospital.

■ TA36

CC- Room 605

Robust Optimization and Learning under Uncertainty

Sponsored: Optimization/Optimization Under Uncertainty

Sponsored Session

Chair: Phebe Vayanos, University of Southern California, Los Angeles, CA, 90089, United States

1 - Robust Optimization with Decision-dependent Information Discovery

Han Yu, University of Southern California, Center for Artificial Intelligence in Society,, Los Angeles, CA, United States, Phebe Vayanos, Angelos Georghiou

We consider two- and multi-stage robust optimization problems in which the decision variables control the time of information discovery. The time of information discovery is decision-dependent and the uncertain parameters only become observable after an often costly investment. We prove and leverage our new model to provide a solution method inspired from the K-adaptability approximation approach, whereby K candidate strategies for each decision stage. We reformulate the problem as an MBLP solvable with off-the-shelf solvers and demonstrate its effectiveness on stylized problems.

2 - Thomson Sampling with Adversarial Data

Chaithanya Bandi, 1987, Evanston, IL, 60208, United States, c-bandi@kellogg.northwestern.edu

Thompson Sampling is one of the oldest and most popular heuristics for multi-armed bandit problems. It is a randomized algorithm based on Bayesian ideas, and has recently generated significant interest after several studies demonstrated it to have better empirical performance compared to the state-of-the-art methods. In this paper, we consider its application in the presence of adversarial corruptions in observed rewards. We show that, ignoring such adversarial corruptions, can lead to linear regret. To remedy this, we present a distributionally robust version of Thomson Sampling that alleviates these problems.

3 - Robust Active Preference Learning

Phebe Vayanos, University of Southern California, Viterbi School of Engineering, Los Angeles, CA, 90089, United States, phebe.vayanos@usc.edu, Duncan McElfresh, John P. Dickerson, Eric Rice

We consider the problem faced by a recommender system that seeks to offer a user their favorite item. Before making a recommendation, the system has the opportunity to elicit the user's preferences by making a moderate number of queries. We propose an exact robust optimization formulation of the problem which integrates the learning (preference elicitation) and recommendation phases and an equivalent reformulation as a mixed-binary linear program. We evaluate the performance of our approach on synthetic and real data from the US homeless youth where we learn the preferences of policy-makers.

■ TA37

CC- Room 606

Learning and Stochastic Optimization

Sponsored: Optimization/Optimization Under Uncertainty

Sponsored Session

Chair: Ruiwei Jiang, University of Michigan, Ann Arbor, MI, 48109, United States

1 - Nonconvex Parameter Search for Stochastic Optimization

Andy (Di Jia) Su, Princeton University, Princeton, NJ, United States, dsu@princeton.edu, Warren Powell

Hyperparameter tuning is very critical in many learning problems. For instance, in stochastic gradient update algorithm, we have $x_n = x_{n-1} + \alpha_n * \nabla F$, we are tuning $\alpha_n $. In can be viewed as a sequential decision problem in which are we assigning α_n at each time step(we called this as the stepsize policy). We understood that there are four classes of policies: CFA, PFA, PFA, and DLA. In the traditional setting, most stepsize policy is handcrafted (for instance, the harmonic stepsize, i.e. PFA). In this talk, we will be tackling this problem from the VFA approach (specifically, Bellman's equation) in the derivative based and the derivative free setting.

2 - A Linear Piecewise Value Function Approximation Policy for Lagged Energy Commitment Problems

Brian H. Cheung, Princeton University, Princeton, NJ, 08540, United States, bcheung@princeton.edu, Warren B. Powell

We present a model of a stochastic lagged resource commitment problem with rolling dynamic forecasts, which we develop in the context of energy portfolio management. Portfolios of energy generators can include steam generators, gas turbines, renewable sources such as wind and solar, as well as storage devices such as batteries; they are characterized by different notification times and efficiencies and together form a rich lagged decision process. We tackle this problem via approximate dynamic programming with piecewise linear approximations to the value functions.

3 - Optimal Online Knowledge Gradient Policy

Donghun Lee, Princeton University, NJ, United States

Please check the mobile app for this abstract.

4 - Online Estimation in Stochastic Optimization Using Variable-Dimensional Learning

Ga Yeong Lee, Princeton University, Princeton, NJ, 08540, United States, gylee@princeton.edu, Warren B. Powell

We consider the sequential decision problem where attribute data arrives randomly over time, and we recommend an offer from a set of discrete offers. We assume that there is a delay in the arrival of feedback, which makes the information collection for one data point expensive. We cluster similar data together and leverage the aggregate information. We propose a variable-dimensional method using ensemble layers of clusters, where we dynamically calculate the weights on each layer at each timestep, according to the inverse mean-squared error rule. We then apply this to a real-life dataset of hotel offer recommendation problem.

5 - Using Radial Basis Functions to Optimize Expensive Functions with Heterogeneous Noise

Yichi Shen, Research Fellow, National University of Singapore, Singapore, 689865, Singapore, isesy@nus.edu.sg, Christine A. Shoemaker

We introduce an algorithm that extends the Metric Stochastic Response Surface (MSRS) approach to optimize functions with heterogeneous noise. The proposed algorithm utilizes Radial Basis Functions (RBFs) as the surrogate and sequentially determines the next expensive evaluation point. In each iteration a new evaluation point is selected in two stages based on the defined metric distances, which capture the trade-off between observation accuracy, exploitation and exploration. Performance of the algorithm is compared with alternative kriging-based algorithms through standard test functions. The numerical results show that the proposed method is more efficient than the prior algorithms.

■ TA38

CC- Room 607

Stochastic Mixed Integer Applications in Energy Systems

Sponsored: Optimization/Optimization Under Uncertainty

Sponsored Session

Chair: Haoxiang Yang, Northwestern University, Evanston, IL, 60208, United States

1 - Optimizing Concentrating Solar Plant Operations and Maintenance under Pricing and Weather Uncertainty

Alexander Zolan, National Renewable Energy Laboratory, Golden, CO, United States, Alexander.Zolan@nrel.gov, Jesse Wales, Alexandra M. Newman, Michael J. Wagner

Concentrating solar power (CSP) technologies utilize the heat from sunlight that is redirected by a field of sun-tracking mirrors to a central location. The heat produced by this process may be (i) converted to electricity using conventional power cycle technology, and/or (ii) paired with thermal energy storage (TES) in the form of molten salts, to be stored for later use. The use of TES makes the electricity produced by CSP highly dispatchable and, therefore, unique among non-hydropower renewable energy resources. We present a collection of models which find operations decisions that minimize operations and maintenance costs in real time, in which weather, pricing, and repair times are uncertain.

2 - A Bundle Method for Bilevel Stochastic Programming with Applications in Risk-averse Decision Making

Deniz Eskandani, Rutgers University, Piscataway, NJ, United States, deniz.eskandani@rutgers.edu, Jonathan Eckstein

We present a proximal bundle method to efficiently find an upper bound for maximizing bilevel stochastic programs. To provide a lower bound, we further propose an approach to find a feasible solution. We implement our algorithm in the gurobipy module of Python and apply it to various classes of problems, including risk-averse supply chain planning, and compare our computational results with the existing mixed integer programming approaches. We find that our approach can provide a better approximation for the optimal solution and can scale to larger problems.

3 - Stochastic Dispatch Optimization for Concentrated Solar Power Systems

Gokce Kahvecioglu, PhD Student, Northwestern University, Evanston, IL, 60208, United States, gokcekahvecioglu2014@u.northwestern.edu, David Morton

Concentrated solar power (CSP) technology with thermal energy storage is dispatchable, i.e., it has the flexibility to adapt power output to the demand. While there are several key advantages of CSP, so-called direct normal irradiance (DNI), the source of power for CSP, is challenging to accurately forecast. We focus on producing scenario-based DNI estimates rather than just a point estimate of DNI via a new sampling method that allows temporal dependence and non-identical errors. We then input the scenarios into the stochastic dispatch optimization model that states how the system should operate over the next few hours, and positions the system to be well-hedged against the set of DNI scenarios.

4 - Microgrid Operations under Stochastic Disruptions

Haoxiang Yang, Northwestern University, Evanston, IL, 60208, United States, haoxiangyang2019@u.northwestern.edu

We propose a robust optimization model for the alternating current optimal power flow (ACOPF) problem and its extensions considering stochastic disruptions. We consider uncertain demand and availability of renewable energy resource, develop a new type of uncertain events named stochastic disruptions, and use an uncertainty set to model it under the context of robust optimization. Based on the convex relaxation schemes for ACOPF problem, we construct a robust convex optimization problem with recourse. We propose a decomposition method with enhancements to solve this problem. Experimental results indicate a tight lower bound and an acceptable solution for the non-convex robust ACOPF problem.

■ TA39

CC- Room 608

Joint Session RAS/Practice Curated: OR/OM Impact on Freight Railway Services

Sponsored: Railway Applications

Sponsored Session

Chair: Steven Harrod, PhD, Technical University of Denmark, Kgs. Lyngby, 2800, Denmark

1 - Efficiency and Effectiveness Analysis of the EU Ten-t Freight Railway Network

Steven Harrod, Technical University of Denmark, Denmark, stehar@dtu.dk, Shengdong Li

The TEN-T network is a designated international set of railway corridors within the European Union for freight transport. Each corridor has its own managing authority, but each corridor also depends on the infrastructure and services of the individual countries through which it passes. This analysis applies data envelopment analysis (DEA) to value both the relative efficiency and effectiveness of each corridor. Efficiency quantifies how well the corridor uses material inputs to produce transportation, and effectiveness quantifies how that raw transportation is actually put to practical use (utilization).

2 - A Collection of Aspects Why Optimization Projects for Railway Companies Could Risk Not to Succeed – A Multi-perspective Approach

Christian Liebchen, Professor for Transportation Operations, TH Wildau, Am Waldberg 22c, Berlin Area, D-12683, Germany, liebchen@th-wildau.de, Hanno Schülldorf

There are more publications on promising projects on how mathematical optimization could improve the performance of railway companies, than success stories in the sense that OR methods really entered the practice of railways. We investigate projects, which finally did NOT enter the practice of railways. We conduct a survey in which we ask railway practitioners (ordering party) and optimization experts (R&D solution provider). We discuss the most frequent replies to our question about the key factors why in the past mathematical optimization methods did not enter the practice of railways. Hereby, we offer a knowledge base to future project managers.(originally presented at ICROMA 2019)

3 - Retrospective Impact of Operations Research & Operations Management on Freight Railway Operations

Marc Meketon, Vice President, Oliver Wyman, Princeton, NJ, 08540, United States, marc.meketon@oliverwyman.com, David T. Hunt

We will review the use of analytical techniques used in the railway industry over the past 100+ years, including time-table development, dispatch optimization, meet-pass planning, local operation optimization, equipment optimization and more.

4 - Service Network Design for China Railway Express under the Belt and Road Initiative Considering Market Competition

Yingzi Peng, Tsinghua University, Beijing, China, pengyingzi288@163.com, Lefei Li

This paper aims to reconstruct the railway service network between China and Europe by considering customers' choice among several transportation modes. In particular, to reflect the decision making process in reality, a bi-level programming model is established to maximize the total profit of the China Railway company in the upper level and to minimize the total disutilites of the customers in the lower level. Diseconomies of sclale is adopted to reflect freight cost structure between hub links. We propose beners decomposition to solve the linearized MIP and use a method to accelerate convergence. Our method offers significant computational benefits compared to commercial solver Cplex.

■ TA40

CC- Room 609

Scalable Algorithms for Nonsmooth and Nonconvex Optimization

Sponsored: Optimization/Nonlinear Programming

Sponsored Session

Chair: Shiqian Ma

1 - Scalable Optimization Algorithms for Subspace Clustering

Daniel Robinson, Associate Professor, Lehigh University, Bethlehem, PA, 21218, United States, Chong You, Rene Vidal

This talk will discuss recent work on developing scalable optimization algorithms for performing the unsupervised task of clustering data drawn from a union of subspaces. Data with such union-of-subspace structure arises in various applications such as face and image clustering, motion segmentation, hybrid system identification, and multiple view geometry.

2 - Stochastic Methods for Nonsmooth Nonconvex Optimization

Dmitriy Drusvyatskiy, Associate professor, University of Washington, University of Washington, Mathematics Department, Seattle, WA, 98195, United States, ddrusv@uw.edu

Stochastic iterative methods lie at the core of large-scale optimization and its modern applications to data science. Though such algorithms are routinely and successfully used in practice on highly irregular problems, few performance guarantees are available outside of smooth or convex settings. In this talk, I will describe a framework for designing and analyzing stochastic methods on a large class of nonsmooth and nonconvex problems, with provable efficiency guarantees. The main thread of the proposed framework is appealingly intuitive. I will show that a wide variety of stochastic methods can be interpreted as inexact gradient descent on an implicit smoothing of the problem.

3 - Stochastic Subgradient Method Converges on Tame Functions

Damek Davis, Cornell University, Ithaca, NY, 14850, United States

This work considers the question: what convergence guarantees does the stochastic subgradient method have in the absence of smoothness and convexity? We prove that the stochastic subgradient method, on any semialgebraic locally Lipschitz function, produces limit points that are all first-order stationary. More generally, our result applies to any function with a Whitney stratifiable graph. In particular, this work endows the stochastic subgradient method, and its proximal extension, with rigorous convergence guarantees for a wide class of problems arising in data science—including all popular deep learning architectures.

4 - An Average Curvature Accelerated Composite Gradient Method for Nonconvex Smooth Composite Optimization Problems

Jiaming Liang, Georgia Institute of Technology, Atlanta, GA, United States, Renato D. C. Monteiro

This talk discusses an accelerated composite gradient (ACG) variant for solving nonconvex smooth composite minimization problems. As opposed to well-known ACG variants which are based on either a known Lipschitz gradient constant or the sequence of maximum observed curvatures, the current one is based on the average of all past observed curvatures. Another feature of it is that it never backtracks.

■ TA41

CC- Room 610

Conic Optimization in Operations Management

Contributed Session

Chair: Joseph Atwood, Montana State University, Ag Econ & Economics, Bozeman, MT, 59717-2920, United States

1 - Coordinating Inventory, Fulfillment and Transshipment Decisions in Omni-channel Stores

Ebrahim Arian, University of Illinois at Urbana-Champaign, Urbana, IL, United States, arian2@illinois.edu, Xin Chen

We analyze a joint inventory, fulfillment, and transshipment control problem for multiple omni-channel stores selling single product over a finite horizon. In each period before demands realization, each store replenishes its inventory and puts a threshold to accept or reject online demands. After fulfilling all possible offline demands, the accepted online demands will be fulfilled with different resources. We develop a dynamic two-stage stochastic programming model which is not convex. We convert the non-convex model to an equivalent convex one and establish the integrality of the optimal solutions of the model. Based on a retailer data, we evaluate the performance of our fulfillment policy.

2 - Optimal Workforce Planning in a Federal Revenue Collection Agency

Rima Gooden, Deloitte Consulting LLP, Arlington, VA, United States, rimagooden@deloitte.com

A large-scale workforce planning and allocation model for a large tax-collecting government agency is considered. The approach maximizes non-linear objective functions subject to geographic and temporal constraints. Two approximation paradigms are considered and compared: i) a linear approximation of the objective function with integer decision variables, and ii) a non-linear objective function with removal of the integrality constraint. The former is solved with standard MIP methodologies, while the latter is solved using disciplined convex programming.

3 - Continuous LP Approximations to NP-hard Portfolio Optimization Problems Subject to VAR or Related Risk Constraints

Joseph Atwood, Montana State University, Bozeman, MT, United States, jatwood@montana.edu

A common class of NP-hard problems involve applications of binary mixed-integer optimization MILP models in which the MILP model endogenously identifies a proportion of constraints that are allowed to violated or "relaxed". This paper presents a continuous LP procedure that quickly obtains approximate solutions to the NP-hard relaxed constraint (RC) problem. The procedure nests the original problem in an LP model allowed to endogenously contort the polytope while also optimizing within a stochastic inequality that guarantees that no more than a given proportion of the original constraints are violated. An application in portfolio optimization is presented.

■ TA42

CC- Room 611

Connected and Interdependent Critical Infrastructure Systems

Sponsored: Optimization/Network Optimization

Sponsored Session

Chair: Zhaomiao (Walter) Guo

1 - Modeling Airline Frequency Decisions in Large Networks with Connections

Vikrant Vaze, Dartmouth College, Murdough Center, Hanover, NH, 03755, United States, vikrant.s.vaze@dartmouth.edu, Reed Harder

We develop a two stage game theoretic model of airline competition, where airlines choose service frequencies during the first stage and set fares during the second stage. First, we show that a simplified version of this game has a credible and tractable subgame perfect Nash equilibrium solution. We then develop a new approximation scheme to show that these properties extend to more realistic models, and enable fast solution of the games. Leveraging these properties, we develop and implement an approach to solve our game for a real-world network, and empirically validate the frequency predictions of our model.

2 - Multi-dimensional Analysis of Critical Network Components

Jeffrey Lineberry, Graduate Student, University of Oklahoma, Norman, OK, United States, Nafiseh Ghorbani Renani, Kash Barker

Critical Infrastructure is an interdependent system of networks that are subject to disruption, and decisions are often necessary to allocate resources to protect before a disruptive event and restore afterward. This work explores a means to identify a critical set of network components along multiple dimensions to which resources will be allocated. A tri-level protection-interdiction-restoration problem will be solved using different sets of these critical components, chosen from different determinants, and a comparison made.

3 - Interdependent Restoration Routing Problem

Nazanin Morshedlou, Mississippi State University, Starkville, MS, United States, nazanin.morshedlou@ou.edu, Kash Barker, Andres David Gonzalez

After disruptions, crews are dispatched from depots to a transportation network to restore disrupted infrastructure networks. The road network itself may be affected by the disruptive event. To restore other networks, we require to restore the connectivity of the transportation network is such a way that the critical components become geographically accessible. This perspective connects the transportation network components to moderate traffic congestion and decrease the evacuation process and expected commuting time. We consider restoration routing optimization to strike a balance between these perspectives and find the optimal synchronized paths for restoration crews.

4 - Power and Transportation System Interdependence: A Stochastic Multi-agent Optimization Approach

Zhaomiao Guo, University of Central Florida, Orlando, FL, 32816, United States

We present a mathematical model that supports renewable energy infrastructure planning under uncertainty. The interdependence between different stakeholders in the system is captured in an energy supply chain network, where new entrants of renewable investors compete with existing generators for natural resources, transmission capacities, and demand markets. Through reformulation, the equilibrium solution of the stochastic energy supply chain planning problem can be obtained through solving traffic network equilibrium problems. Establishing such a connection has a potential for improving the computational efficiency in large scale power system problem.

5 - Designing Corridor Systems with Modular Vehicles Enabling En-route Docking: Continuous and Discrete Modeling Methods

Xiaopeng Li, University of South Florida, Tampa, FL, 33620, United States, Zhiwei (Nicklaus) Chen

This study proposes two modeling methods, i.e. continuous and discrete models, to jointly design the dispatch headway and capacity for corridor systems. The continuous model presents a macroscopic view of the system and yields a sub-linear time complexity solution method that can achieve near-optimal solutions to the investigated problem very efficiently. The discrete modeling method, however, takes a microscopic point of view and yields exact optimal solutions with a tailored branch-and-bound algorithm.

■ TA43

CC- Room 612

Boosting Combinatorial Optimization using Machine Learning

Sponsored: Computing

Sponsored Session

Chair: Quentin Cappart, QC, Canada

1 - Learning a Cutting Plane Selection Policy

Antoine Prouvost, Polytechnique Montréal, Montréal, QC, Canada, Aleksandr M. Kazachkov, Andrea Lodi

Cutting planes are one of the main drive in mixed-integer linear programming. We propose to learn a policy to filter rounds of cuts through self supervised deep reinforcement learning. Our approach models mixed-integer linear programs as a bipartite graph and leverage graph neural networks to learn the selection policy though policy gradient ascent. We apply our methodology to a distribution of 2-matching instances and aim to solve them with a minimal number of cuts.

2 - Graph Convolutional Neural Networks for the Travelling Salesman Problem

Chaitanya Joshi, Nanyang Technological University, Singapore, Singapore

The most famous NP-hard combinatorial problem today, the Travelling Salesman Problem, is intractable to solve optimally at large scale. In practice, existing techniques such as Concorde can efficiently solve TSP up to thousands of nodes. This talk introduces a recent line of work from the deep learning community to directly 'learn' good heuristics for TSP using neural networks. Our approach uses Graph ConvNets to operate on the graph structure of problem instances and is highly parallelizable, making it a promising direction for learning combinatorial optimization at large scale.

3 - Learning for Cutting Planes

Elias B. Khalil, Postdoctoral Scholar, Polytechnique Montréal, Montreal, QC, 30309, Canada, lyes@gatech.edu

Cutting Planes (or cuts) are a fundamental tool in solving Mixed Integer Programming (MIP) problems. Despite their mathematical underpinnings, cuts in MIP solvers are generated and selected using heuristic procedures. I will explore the potential for using Machine Learning to help in the process of cut generation.

4 - Janos: Integrated Predictive and Prescriptive Modeling Framework

Teng Huang, University of Connecticut, Storrs, CT, United States, teng.huang@uconn.edu, David Bergman, Philip Brooks, Andrea Lodi, Arvind Raghunathan

Business research practice is witnessing a surge in the integration of predictive modeling and prescriptive analysis. We describe a modeling framework JANOS seamlessly integrates the two streams enabling practitioners to make optimal data-driven decisions. JANOS allows for specifying a prescriptive model using the standard optimization modeling elements such as constraints and variables. The key novelty lies in modeling constructs allow for the specification of commonly used predictive models and their features as constraints and variables in the optimization model. We demonstrate the flexibility of the framework through two examples in workforce allocation and student enrollment.

■ TA44

CC- Room 613

Joint Session ICS/Practice Curated: Rigorous Foundations for Cybersecurity Science Based in Operations Research

Sponsored: Computing

Sponsored Session

Chair: Jean-Paul Watson, Sandia National Laboratories, Albuquerque, NM, 87113-2065, United States

1 - Solving Energy System Models with GAMS on HPC Platforms

Michael Bussieck, GAMS, Braunschweig, Germany

GAMS is a widely used platform to implement Energy System Models (ESM) like unit commitment, optimal power flow, and economic dispatch. Such models developed and maintained by (academic) research institutes, multi-national organizations, and commercial companies often evolved over time and represent sophisticated and intricate software systems. The modeled time horizon of ESMs spans decades and due to open markets for electricity these models cover bigger and bigger regions. Hence ESMs tend to push the boundaries of available computational resources. In the last three years a multidisciplinary team of researchers from ZIB/TU Berlin/JSC/HLRS/GAMS/DLR investigated ways to handle linear programming based ESMs of exceptional size in a project named BEAM-ME (http://www.beam-me-projekt.de/beam-me/EN/Home/home_node.html). We will give an overview of the various activities in this project and emphasize on challenges related to migrating GAMS based ESMs to a high-performance computing environment.

2 - Cyber Threat Modeling and Validation

Eric Vugrin, Sandia National Labs, Albuquerque, NM, United States, Gerardo Cruz, Christian Reedy, Alexander Outkin, Vincent Urias, Thomas Tarman

The Science and Engineering of Cybersecurity by Uncertainty quantification and Rigorous Experimentation (SECURE) project aims to develop new cybersecurity modeling and analysis tools that implement rigorous, scientific experimental methods. One of SECURE's key research challenges is credible representation of cyber threats and attacker strategies in cybersecurity models. This presentation describes the SECURE project's approach to integrating mathematical models and network emulations for developing and validating cyber threat models. This approach is demonstrated in a scenario involving network scanning by an attacker and intrusion detection by a system operator.

3 - Uncertainty Quantification in Cyber Emulation

Laura Painton Swiler, Sandia National Labs, Albuquerque, NJ, United States

As cyber researchers increasingly rely on virtualized testbeds, there is a need to use uncertainty quantification to generate ensembles of cyber experimental runs or emulations. Principled statistical approaches can provide rigor in analyzing results and support inferences made from such results. In this paper, we outline sampling approaches that can be used to design experiments for emulation testbeds, including orthogonal arrays, Monte Carlo sampling, and multifidelity uncertainty quantification. We present results and lessons learned.

4 - Bilevel Optimization of Cyber Physical Models for Power Grid Resilience

Bryan Arguello, Sandia National Labs, Albuquerque, NM, 87111, United States

We discuss state-of-the-art for bilevel optimization applied to defender-attacker and attacker-defender Stackelberg games on cyber-physical infrastructures. In particular, we extend seminal work in this area on power grid resilience to incorporate ICS/SCADA topologies, threat models, and cybersecurity-based mitigation strategies. We discuss some of the difficulties in model fidelity due to formulation abstraction, and potential solution techniques to solve these problems at scale. We conclude with some preliminary results and future directions for our work.

■ TA45

CC- Room 614

Large Scale and Distributed Optimization II – in Memory of Wei Shi

Sponsored: Optimization/Nonlinear Programming

Sponsored Session

Chair: Wotao Yin

Co-Chair: Fatemeh Mansoori, Northwestern University, Evanston, IL, 60202, United States

Co-Chair: Ermin Wei, Northwestern University, Evanston, IL, 60208, United States

1 - Distributed Zero-order Algorithms Nonconvex Optimization

Yujie Tang, Harvard University, Cambridge, MA, 91125, United States, yujietang@seas.harvard.edu, Na Li

Most existing distributed algorithms assume knowledge of first-order information of the objective, which may not be available when one can only evaluate the function values at finitely many points. In this talk we develop derivative-free distributed algorithms for nonconvex consensus-based convex optimization, based on recent progress in zero-order optimization. We establish convergence of the proposed algorithms, and provide some applications in distributed learning where one can employ the proposed algorithms to develop model-free methods.

2 - Lazy Aggregation for Communication-efficient Distributed Learning

Tianyi Chen, Rensselaer Polytechnic Institute, Troy, NY, United States, Georgios Giannakis, Tao Sun, Wotao Yin

Considering the massive amount of devices, centralized machine learning via cloud computing incurs considerable overhead, and raises serious privacy concerns. Today, the consensus is that future machine learning tasks have to be performed starting from mobile devices. In this context, we will highlight key challenges, including communication overhead and heterogeneity. We will introduce a new class of (stochastic) gradient methods for distributed machine learning that adaptively skip the gradient calculations to learn with reduced communication and computation. Our methods enabled by the key idea of lazy aggregation are simple to implement, and come with rigorous performance guarantees.

3 - Decentralized Second-order Methods for Consensus Optimization

Aryan Mokhtari, Massachusetts Institute of Technology, Cambridge, MA, 02139, United States

In this talk, we study decentralized consensus optimization problems where different summands of a global objective function are available at nodes of a network that can communicate with neighbors only. In particular, we focus on developing algorithms for consensus optimization when we have access to high-order information of local functions. We first talk about a decentralized quadratically approximated ADMM algorithm (DQM), which minimizes a quadratic approximation of the objective function that ADMM minimizes at each iteration. Then we talk about extending the use of second-order methods to the framework of augmented Lagrangian methods.

4 - Randomized Primal-dual Block-coordinate Algorithms for Asynchronous Distributed Optimization

Lin Xiao, Microsoft, Redmond, WA, United States, Adams Wei Yu, Qihang Lin, Weizhu Chen

Machine learning with big data often involves large models, and frequent communication and synchronization of all model parameters can be very costly. A promising solution is to use parameter servers to store different subsets of the model parameters, and update them asynchronously at different machines using local datasets. We focus on distributed optimization of large linear models with convex loss functions, and exploit their structure by doubly stochastic coordinate optimization with variance reduction (DSCOVR). Compared with other first-order distributed algorithms, we show that DSCOVR may require less amount of overall computation and communication, and less or no synchronization.

■ TA46

CC- Room 615

Design and Control of Shared Mobility Services

Sponsored: Transportation Science & Logistics/Intelligent Transportation Systems (ITS)

Sponsored Session

Chair: Michael Hyland, University of California, Irvine, CA, 92697-3600, United States

1 - Dynamic Pricing for Ride Pooling Systems

Kai Yang, Wayne State University, Detroit, MI, 48201, United States, Mohammad Abdollahi

We propose a queuing theoretic framework for optimal dynamic pricing of ride pooling systems. Specifically, we focus our attention on dynamic element of pricing meaning that the price can react to online changes of supply-demand balance and will make the system more robust and controllable by pricing dynamically. The dynamic pricing will not basically achieve better performance compared to static pricing, however, it lets the system to realize the benefits of optimal static pricing even with imperfect information in the system.

2 - Hierarchical Control Framework for Autonomous Mobility-on-demand

Kaidi Yang, Stanford University, Stanford, CA, United States, ykd07@stanford.edu, Marco Pavone

We propose a hierarchical control framework for Autonomous Mobility-on-demand where self-driving vehicles serve on-demand travel requests. The road network is divided into several subnetworks based on network topology, demand, traffic conditions, etc. The control framework builds on a network flow model and consists of two levels: 1) an upper level that optimizes the traffic flow (passenger and rebalancing flow) between subnetworks, and 2) a lower level that optimizes the traffic flow within each subnetwork, considering the upper-level control decisions. Results show that the proposed hierarchical control framework can reduce the computation time while yielding satisfactory solutions.

3 - Travel Pattern and Emission Implications in a Fleet of Conventional, Autonomous and Shared Autonomous Vehicles

Harprinderjot Singh, Michigan State University, East Lansing, MI, United States, singhh24@msu.edu, Mehrnaz Ghamami, Hadis Nouri, Timothy Gates

Autonomous and Shared Autonomous Vehicles (AV/SAVs) can improve roadway capacity, driver productivity and mobility in a transportation system. However, the adoption of these vehicles will increase vehicle miles traveled (VMT) which can increase travel time and emission production in the system. The higher purchase price of AVs may also hinder the adoption of these vehicles. This study first models and calibrates the above functions, and then captures the trade-off between the above factors to estimate the optimum fleet configuration resulting in maximum system benefits.

4 - Optimal Design of Mobility Service Networks Based O\ON Travel Dispersion

Navjyoth Sarma, University of California, Irvine, Irvine, CA, United States, nsarma.js@uci.edu, Michael Hyland

Emerging mobility modes such as flexible transit and ride-sharing have the potential to substitute or complement segments in a fixed transit network. This study aims to find the optimal integrated mobility service network with fixed and flexible components. As a critical first step in the mobility service network design problem, this study presents a method to quantify travel dispersion in a region considering the spatial distribution of trips and the underlying transportation network. Then, using parsimonious analytical models, we aim to determine a generalizable relationship between travel dispersion and the optimal combination of mobility service modes to serve the region.

5 - How Can Taxis Up Their Games in the Age of Uber

Shih-Fen Cheng, Associate Professor, Singapore Management University, Singapore, Singapore, sfcheng@smu.edu.sg, Shashi Shekhar Jha, Rajendram Rishikeshan

Taxis are facing stiff competitions from new technology platforms such as Uber globally. In this talk, I will discuss how big data analytics and data-driven decision support can help us improve taxi industry's competitiveness. In particular, I will discuss how to derive insights on demand and supply from raw taxi traces, and how we can estimate demand and supply imbalances. To address these imbalances, we have developed the Driver Guidance System (DGS), which aims to provide driver-specific recommendations to maximize driver's revenue. The DGS has been tested for more than 3 years; with over 500 drivers, we show that driver's vacant roaming time can be reduced by 27% if drivers follow our guidance.

■ TA47

CC- Room 616

Data Science and Machine Learning for Critical Infrastructures (Transportation, Cyber, Power, etc.)

Sponsored: Transportation Science & Logistics

Sponsored Session

Chair: Tingting Zhao, University of South Florida, Tampa, FL, 33612, United States

1 - Exploring Insignificant OD Pairs: A Compressed Sensing Model for OD Demand Estimation

Xuegang Ban, University of Washington, Seattle, WA, United States, banx@uw.edu, Jingxing Wang

Origin-Destination demand is critical for many transportation applications. Given the fact that in the real-world OD matrix, the majority of OD pairs own small demands while only a small portion have high demands, this study proposes a compressed sensing-based OD estimation model that tries to retain the insignificance feature of OD matrices. The compressed sensing technique is employed in this model to guarantee the sparsity of the deviations between estimates and its prior information or newly-acquired field data. We propose a sufficient condition that can guarantee the insignificance feature of OD matrices. The uniqueness condition for model solution is also investigated for this model.

2 - List-wise Ranking Method for Transportation System Restoration Resource Allocation

Tingting Zhao, University of South Florida, Tampa, FL, 33612, United States, tingtingzhao@mail.usf.edu, Yu Zhang

The performance evaluation for transportation network with several links disrupted is inevitable for the restoration resource allocation. Conventional optimization-based problem formulations are challenging to be solved efficiently as they are combinatorial problems. We proposed a machine-learning framework to address this problem. Both topological and network-flow features are considered for network feature matrix generation. A supervised list-wise ranking model is proposed to rank the performance of a given list of transportation networks with different disrupted links. Our results show that this approach can efficiently assist in transportation restoration resource allocation.

3 - Synthetic Data Generation for Interdependent Food-Energy Systems

Charalampos Avraam, Johns Hopkins University, Baltimore, MD, United States, cavraam1@jhu.edu, Sauleh Ahmad Siddiqui, Emma Cogan, Roni Neff

The regional nature of critical interdependent infrastructures, such as the food and energy systems, requires modelers to extend their analysis to a level of detail that is often more granular than the available data. To generate these synthetic data, we pose the problem of generating candidate values and uncertainty bounds on the required data as a Mathematical Program with Equilibrium Constraints and propose a two-stage decomposition to significantly reduce computational time. In the first stage, the sub-modules are individually calibrated and in the second stage the data at the inter-dependencies are generated. We test our method by linking a US food model with an energy module.

4 - Optimal Network System Restoration Regarding Cascading Failures using Reinforcement Learning

Jian Zhou, Rutgers University, Somerset, NJ, 08873, United States, Dali Wang, David W. Coit

A new approach is proposed to help rapidly identify important system components to mitigate cascading failures impact within large scale networks. It provides distinct advantages to stop failure propagation by efficiently identifying critical system components denoted by minimum vertex cover. Our method adopts graph embedding techniques to represent the characteristics of network systems, and then uses deep reinforcement learning to quickly detect minimum vertex cover from the real-time system topology changed by cascading failures. A case study on western U.S. power transmission grid is presented to illustrate the problem formulation procedures and demonstrate the practical usefulness.

■ TA48

CC- Room 617

Models for Logistics Capacity Planning and Flexible Urban Delivery

Sponsored: Transportation Science & Logistics/Freight Transportation & Logistics

Sponsored Session

Chair: Teodor Gabriel Crainic, Université du Quebec a Montreal, School of Management, Department of Management & Technology, Montréal, QC, H3C 3P8, Canada

1 - Flexible Urban Delivery and On-demand economy: The Case of a Medium-Sized City

Guido Perboli, Politecnico di Torinbo, Turin, Italy, guido.perboli@polito.it, Luce Brotcorne, Maria Elena Bruni, Mahamud Hasan

We focus on the decision maker adopting a satellite and distributing from there through contracted vehicles. In particular, he can adopt mixed-fleet composed by traditional vehicles, low-environmental vehicles or traditional vehicles owned by unprofessional users. We model this problem by proposing a new variant of the bin packing problem Variable Size Cost Bin Packing Problem (VCSBPP) with time-dependent cost, in which we consider a generalized objective function, represented by a generalized cost given by the cost of the warehouse and the delivery cost represented by the routing costs of electric vehicles at a specific time slot. Results from a case study on the city of Turin are presented.

2 - Capacity Planning with Uncertainty on Contract Fulfillment

Walter Rei, University of Quebec-Montreal, 10673 Larose, Montreal, QC, H2B 3C4, Canada, rei.walter@uqam.ca, Teodor Gabriel Crainic, Guido Perboli, Mariangela Rosano

We focus on the problem faced by a shipper seeking to secure different transportation and warehousing capacity units provided by a carrier while facing various sources of uncertainty in the planning context. In particular, we consider that the contracted capacity may not be entirely available at the shipping day following different unfavorable situations. We thus introduce an extended Stochastic Variable Cost and Size Bin Packing model to formulate the problem and apply solution methods to solve it. Numerical experiments were conducted on both long-haul transportation and urban distribution problems, providing some relevant managerial insights regarding this type of capacity planning.

3 - Multi-period Bin Packing Models for Logistics Capacity Planning

Franklin Djeumou Fomeni, Postdoctoral Researcher, University of Quebec in Montreal, Pavillon Andre-Aisenstadt, 2920 Chemin de la Tour, Montreal, QC, H3T 1J4, Canada, franklin@aims.ac.za, Teodor Gabriel Crainic, Walter Rei

We present a multi-period bin packing model which has practical applications in logistics planning. This model is aimed at minimizing, simultaneously, the cost of selecting the bins and the costs of assigning items to bins, which may depend on other criteria than the volumes of the items as assumed in most existing bin packing models. We show that in some practical applications, such as multi-modal logistics systems, the cost of assigning an item to a bin needs to account for both the physical characteristics of the bins and other economical attributes of the system. A constructive heuristic framework for solving the model will be presented. Some computational results will also be discussed.

4 - An Integrated Location-routing Model for a Hybrid Uav-based Delivery System

Lavinia Amorosi, PhD, Universita di Roma - La Sapienza, Roma, Italy, lavinia.amorosi@uniroma1.it, Teodor Gabriel Crainic, Paolo Dell'Olmo, Nicoletta Ricciardi

Unmanned aerial vehicles (UAVs) have been adopted in a number of cases [1] and applications to delivery systems have recently received considerable attention. In this talk, we present a multiperiod location-routing problem of one truck and a set of UAVs for package delivery in an urban area. Following work [2] we present solution method and preliminary computational results. [1] Otto A. et al., Optimization approaches for civil applications of unmanned aerial vehicles (UAVs) or aerial drones: A survey, Networks 72 (2018) 411-458.[2] Amorosi L. et al., Energy-Efficient Mission Planning of UAVs for 5G Coverage in Rural Zones, IEEE International Conference on Environmental Engineering, EE 2018, 1-9.

■ TA49

CC- Room 618

Joint Session TSL/Urb/Practice Curated: Shared Mobility Systems: Operations and Economics II

Sponsored: Transportation Science & Logistics/Urban Transportation

Sponsored Session

Chair: Neda Masoud, University of Michigan, Ann, MI, 48109, United States

1 - A Data-driven Optimization Approach for Dynamic Shuttle Dispatching Problem

Amirmahdi Tafreshian, University of Michigan, Ann Arbor, MI, 48109, United States, atafresh@umich.edu, Mojtaba Abdolmaleki, Neda Masoud

The problem of dispatching shuttles to serve trip requests can be mathematically formulated as a dial-a-ride problem (DARP). With on-demand mobility services gaining more popularity in recent years, the real-time application of DARP is attracting ever more interest. However, the fact that size of DARP grows exponentially with number of requests renders the current solution methodologies inadequate for online applications. In order to tackle this issue, we propose a general framework that shifts much of the computational burden of the optimization problems that need to be solved into an offline setting, thereby addressing on-demand requests with fast and high-quality solutions in real time.

2 - Analysis of the Impact of Regulation in the Ride-sourcing Market

Daniel Vignon, University of Michigan, Ann Arbor, MI, 48105, United States, dvignon@umich.edu, Zhengtian Xu, Yafeng Yin

Despite their increasing popularity, ride-sourcing platforms like Uber and Didi face mounting pressure from political and regulatory agents. Especially, given the mounting evidence that these services contribute to congestion, there is increasing support for regulations that addresses the aforementioned externality. However, there is also a need to understand the potential impact of proposed measures—such as congestion pricing or fleet size caps—on service quality and accessibility. Thus, in this work, we propose a model of the ride-sourcing market and explore the potential impact of popular measures aimed at reducing ride-sourcing generated congestion.

3 - Data-driven Matching for Ride Sharing System Using Trajectory Data and Dynamic Time Warping

Alexander Sundt, University of Michigan, Ann Arbor, MI, United States, asundt@umich.edu, Mehrdad Shahabi, Yafeng Yin

Recent research in ride-sharing has focused heavily on real-time systems and the implementation of their matching algorithms, but has overlooked user history in facilitating these matches. In order to bridge this gap, we present a robust optimization formulation to match users for ride-sharing based on their historical trajectory data. Using modifications to the dynamic time-warping algorithm, we obtain approximate distances between trajectories and we present centralized and decentralized formulations for matching users based on these distances. The procedure is tested on a small toy dataset as well as the large Microsoft GeoLife dataset.

4 - Modelling Impact of Demand Shocks in Pricing of Ride-hailing Services

Sohil Shah, MIT, Cambridge, MA, United States, sshah95@mit.edu, Saurabh Amin, Patrick Jaillet

Demand fluctuations for ride-hailing services have been classically dealt with by setting market clearing prices. However, little is known about strategic pricing after demand shocks such as those following sporting events and disruptions in public transit. We present a network queuing model that captures the interaction between the dynamics of rider requests and pricing strategies employed by employed by ride-hailing services in areas adjacent to a demand shock. We validate the model using data collected after the conclusion of baseball games in the Boston Area.

■ TA50

CC- Room 619

Joint Session TSL/Air/Practice Curated: Planning and Operations for Smart City

Sponsored: Transportation Science & Logistics/Facility Logistics

Sponsored Session

Chair: Xin Wang, University of Wisconsin-Madison, Middleton, WI, 53562-4278, United States

1 - Longitudinal Trajectory Control of Connected Autonomous Vehicle with Deep Reinforcement Learning

Xiaopeng Li, University of South Florida, Tampa, FL, 33620, United States, xiaopengli@usf.edu, Yu (Crystal) Wang

We develop a dynamic data-driven control architecture to optimize the trajectory of Connected Autonomous Vehicle. We adapt controller parameters by training an artificial neural network and minimize the fuel consumption without sacrificing safety or efficiency with the reinforcement learning method. The proposed controller over-performs human and Cooperative Adaptive Cruise Control method.

2 - Optimal Charging Plan for Electric Vehicles: Dynamic Scheduling under User Decisions

Leila Hajibabai, North Carolina State University, Department of Civil Engineering, Raleigh, NC, 11794, United States, lhajiba@ncsu.edu, Amir Mirheli

This study develops a dynamic scheduling scheme for electric vehicle (EV) charging facilities that aims to determine the demand-based assignment of EV users to the facilities considering their waiting time and time-window constraints. The problem is formulated into a dynamic programming model that minimizes the (i) total costs including travel and charging expenses and (ii) number of un-served users, under uncertain demand and charger availability. A stochastic look-ahead technique is proposed that integrates Monte Carlo tree search algorithm and shooting heuristic. Numerical experiments confirm the quality and efficiency of solutions obtained from the proposed methodology.

3 - An Exchange Market Platform for Parking

Xin Wang, University of Wisconsin-Madison, Middleton, WI, 53562-4278, United States, Xiaotian Wang

Parking difficulties in urban areas cause cruising traffic, which leads to a series of social and economic problems. A few reservation-based parking management strategies have been proposed to eliminate cruising, while they have a high level of requirements on the infrastructure, which is unrealistic in most cases. To solve parking problems without restrictions on the infrastructure, we build a parking spot exchange market where parking availability information is treated as a merchandise to trade. To be specific, an arriving driver pays to get a specific parking spot from another driver who is about to depart. Social objective is considered, and pricing is centralized to avoid discrimination.

4 - A Deep Model-based Deep Q-learning Algorithm for Traffic Signal Timing at Urban Intersections

Yun Yuan, Postdoctoral Research Associate, The University of Utah, Salt Lake City, UT, United States, yun.yuan@utah.edu, Hao Wang, Tian Zhao, Yang Liu, Xianfeng (Terry) Yang

This study employs a Deep Q-learning Learning method and Deep Q neural network for traffic signal split optimization problem at an urban intersection. To accelerate the training computation, a deep model is investigated to extract features and predict states from flawed data. The deep model outperforms simulators regarding the running time. The proposed method is tested on a real-world testbed with Automatic Number-Plate Recognition data. The case study shows the deep model can predict the traffic state in limited computational time and the deep Q-learning algorithm is 3.9% better than the field data of the adaptive control system SCOOT and 22% better than the time-of-day plan by SYNCHRO.

5 - Operational Models for Smart Unmanned Aerial Mobility Networks

Qiao-Chu He, Southern University of Science and Technology (SUSTech), Shenzhen, China, heqc@sustech.edu.cn, Lan Lu, Lishuai Li, Zheng Zhu

Smart logistics enabled by the sophistication of unmanned aerial vehicles (UAVs), is in multiple dimensions: (1) from hardware design to service platform driven by data and algorithms; (2) from uncoordinated fleet of vehicles towards logistics-as-a-service paradigm. We investigate this emerging service operations by proposing an integrated systems models: At a strategic level, we design the infrastructures, including airport location/capacity and types of UAVs; At a tactic level, we optimize the logistics network; At an operational level, we develop scheduling algorithms. We work with a leading industry partner whose UAVs logistics service network is already operational.

6 - Optimizing Water Pollution Monitoring Systems: Regulation Policy Guideline for Curbing Nutrient Pollution

Xin Wang, University of Wisconsin-Madison, Madison, WI, United States, Michael Lim, Jeffrey Linderoth

We consider regulatory policy guidelines for improving the surface water quality. Specifically, we establish a practical water pollution regulation system by determining the optimal location of monitor stations along with proper regulatory schemes to curb the nutrient pollution resulting from various farming activities. We develop a central planner's monitoring system optimization model along with analysis methodologies. We construct an innovative computational solution method for optimizing and analyzing the above model for a large-scale water network, and implement the model to Mississippi River Watershed. The proposed modeling framework and solution method is applicable to any general water network, and thus can be further implemented to other water networks in any other region.

■ TA51

CC- Room 620

Joint Session AAS/TSL Air/Practice Curated: Airline Delay and Recovery

Sponsored: Aviation Applications

Sponsored Session

Chair: Yifei Sun, Dartmouth College, Lebanon, NH, 03766, China

1 - Preemptive Rerouting of Airline Passengers under Uncertain Delays

Lindsey McCarty, Cedarville University, Cedarville, OH, 48105, United States, lasel@umich.edu, Amy Cohn

An airline's operational disruptions can lead to flight delays that in turn impact passengers, not only through the delays themselves but also through possible missed connections. We consider preemptive rerouting of airline passengers before the length of the delay is realized. We consider the simplified version in which only a single flight is delayed, and model this problem as a two-stage stochastic programming problem. We present a Benders Decomposition approach and give computational results to demonstrate the reasonable run time in solving our model. This research lays the groundwork for the more-realistic case in which multiple flights in the network may experience concurrent delays.

2 - A Column Generation-based Heuristic for Aircraft Recovery Problem under Typhoon Disruption

Lei Zhou, Tongji University, Shanghai, China, zjzhoulei@tongji.edu.cn, Zhe Liang

Airline aircraft recovery problem (ARP) is the essential part of the schedule recovery process, which is to re-schedule flights and re-assign aircraft. We consider the ARP under typhoon disruption, and propose a mixed integer programming model with considerations in actual business scenarios. We solve the model with a column-generation based heuristic consisting of a master problem for selecting routes and sub-problems for generating better routes for each aircraft. A real-world problem with complicated constraints can be solved to near optimal within 20mins. Our recovery model and solution method has been applied in the decision support system of a Chinese airline.

3 - Integrated Recovery of Aircraft and Passengers Considering Passengers' Irrational Choice

Yuzhen Hu, Harbin Engineering University, Zhongguancun East Road, Harbin, China, hyzshd@126.com, Pu Zhang, Song Zhang, Yizheng Yang, Bo Fan

The consideration of passengers' irrational choice in the optimization research of airline disruption management will reverse the undesirable situation of concerning interests of company but passengers' demands, and emphasizing explicit cost but recessive cost during airlines' flight rescheduling, and thereby reduce dual losses of airlines and passengers. This research focuses on the multiple objective optimization problem of integrated recovery of aircraft and passengers with choice preference between endorsing and ticket refunding. Additionally, passengers' irrational psychology, based on prospect theory, is reflected in the second objective.

4 - Introducing New Flights under Departure Time Dependent Passenger Demand Uncertainty

Ozlem Cavus, Bilkent University, Department of Industrial Engineering, Ankara, 06800, Turkey, ozlem.cavus@bilkent.edu.tr, Ozge Safak, Selim Akturk

We accommodate new flights into an existing airline flight schedule by considering passenger demand uncertainty. To open up space for new flights, we not only make operational changes like shifting the departure times of current flights and adjusting the aircraft cruise speed, but also introduce a more strategic decision of leasing an aircraft. We also consider the effect of departure times of new flights on the distribution of passenger demand. We introduce a unified two-stage stochastic mixed-integer nonlinear programming formulation for the problem and suggest an exact solution algorithm.

■ TA52

CC- Skagit 1

Joint Session RMP/Practice Curated: Data Driven Models for Revenue Management and Pricing in Industry

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Ravi Kumar

1 - A New Approach to Price Optimization

Richard Liu, SAS Institute, Inc., Cary, NC, 27513, United States, Richard.Liu@sas.com, Matthew Maxwell

We develop a new approach to estimate the price to maximize expected revenue. Unlike in an estimate-then-optimize approach, we do not use any parametric model for the random demand. This allows us to work with limited historical data, where only prices, final sold, and final revenue are observed at the end of a selling horizon. We find via simulation that our approach is accurate and robust.

2 - Cancellation Predictors in Airlines and Hospitality

Ger M. Koole, Vrije Universiteit Amsterdam, Department of Mathematics, De Boelelaan 1081A, Amsterdam, 1081 HV, Netherlands, ger.koole@vu.nl, Daniel Hopman, Jeroen de Korte

We use machine learning techniques to predict which customer will cancel their reservations in an airline and in a hotel case.The results are surprisingly accurate, and we show how to use these results to determine the optimal overbooking limit.

3 - Dynamic Pricing for Ancillaries in Travel Industry

Ravi Kumar, Senior Scientist, PROS Inc, Houston, TX, 77098, United States, Guangrui Xie, Ang Li

In recent times, ancillaries have become a key driver for revenue growth for travel industries. Traditionally, pricing and offer generation for ancillary items have been managed using static business rules. In such scenarios, where historical prices show very little or no variation, typical methods of estimating purchase probabilities and then finding the optimal price are not applicable. In this study, we develop practical approaches for dynamic pricing of ancillaries based on reinforcement learning ideas and demonstrate using simulations that these methods can efficiently discover the optimal price.

4 - Medium Term Revenue Management in Air Cargo

Dirk Sierag, PROS Inc, Houston, TX, United States

There are two revenue management problems in Air Cargo: medium term and short term. Short term deals with adhoc sales, which is similar to the passenger airline problem. Medium term deals with seasonal contracts, where clients reserve space on recurring flights or origin-destinations over several months. We solve the medium term problem using a data-driven approach in two steps: (1) determine how much space to allocate for the contracts and how much for adhoc sales; (2) solve the medium term problem using flexible products.

■ TA53

CC- Skagit 2

Recent Advances in Revenue Management

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Jue Wang, Smith School of Business, Queen's University, Kingston, ON, K7L 3N6, Canada

1 - Optimal Inventory Decisions When Offering Layaway

Stanko Dimitrov, University of Waterloo, Waterloo, ON, Canada, sdimitrov@uwaterloo.ca, Oben Ceryan

Layaways allow budget constrained consumers, with sufficiently high valuations to acquire products without using high-cost financing, by reserving the right to purchase a product over time. However, a retailer, offering layaway, may lose opportunities to sell a product to a non-layaway consumer only to have the layaway canceled. In our work, we derive optimal order quantities of a retailer offering layaway, and the market conditions in which a retailer is better off offering layaways. We conclude by considering some timing issues in layaways.

2 - Which Customers Are More Valuable in Dynamic Pricing Situations?

Anton Ovchinnikov, Queen's University, Kingston, ON, K7L 3N6, Canada, ao37@queensu.ca, Jue Wang

Firms commonly rely on cash-flows attributed to a customer relationship to measure customer value. We show that this approach could be potentially flawed when firms operate in dynamic pricing situations with limited capacity: a customer who pays less can have a higher value than one who pays more, and the expected value of a customer could be, independent of, or even decrease in, the price paid by (cash-flow received from) the customer. That said, we also show that certain non-stationary customer arrival patterns could restore the "intuitive" directional relationship that higher-paying customers are more valuable.

3 - Finite-Horizon Decomposition for an Infinite-Horizon Dynamic Capacity Allocation Problem

Rui Zhang, University of Colorado Boulder, Boulder, CO, United States, Thomas Vossen

A rolling-horizon dynamic capacity allocation problem can be formulated as an infinite-horizon discounted cost Markov decision process. We show that the problem can be decomposed by the resources over the booking horizon. The solutions provide upper bounds and can be used to construct heuristic control policies. Computational results are discussed.

4 - Quantifying Mileage Runs: Strategic Consumer Behavior in Premium-Status Loyalty Program

Yang Chen, Queen's University, Kingston, ON, K7L 4A9, Canada, Anton Ovchinnikov

We report on the results of a large-scale field quasi-experiment done in partnership with a major loyalty program to understand strategic consumer behavior with respect to the premium status tier reward. We find that strategic behavior is quite pronounced and adds to nearly 4% increase in the target group's spending. However, we also observe on substantial heterogeneity in consumer behavior, which aligns with the existing theory and enriches the existing empirical evidence of strategic consumer behavior.

■ TA54

CC- Skagit 3

New Directions in Pricing and Revenue Management

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Georgia Perakis

1 - Promotions with Rewards Programs: Improving Fast-food Chain Operations

Rim Hariss, McGill University, Operations Research Center, 1 Amherst Street, Montreal, QC, 02142, Canada, rhariss@mit.edu, Georgia Perakis, Yanchong Zheng

In this work, we study the problem of deciding price discounts while accounting for the effect of the rewards program on demand. Using a partially linear model, we embed the impact of different classes of customers points balance on price sensitivity in demand estimation. We consider the store's problem of maximizing total expected revenue over time by deciding discounts for every period and accounting for the customers redemption behavior. We show conditions under which a unique optimal threshold discounting policy exists. Using data from a fast food chain, we then perform counterfactual analysis to evaluate the revenue improvement of the proposed optimal strategy relative to current practice.

2 - Managing in-class-fulfillment at a Large Fashion E-retailer

Yiannis Spantidakis, MIT, Cambridge, MA, United States, yspant@mit.edu, Georgia Perakis, Divya Singhvi

We consider the problem of optimizing initial inventory distribution for one of the largest fashion retailers in India in order to maximize in-class fulfillment. We formulate this problem as a multi-product, multi-warehouse newsvendor problem with capacity and depth constraints, and propose an efficient iterative algorithm to optimize the inventory distribution. With our industry partner, we run a nation-wide pilot and observe considerable gains in the in-class-fulfillment.

3 - Increasing Healthy Food Consumption Among Low-income Populations

Elisabeth Paulson, MIT, Cambridge, MA, 16801, United States, epaulson@mit.edu, Retsef Levi, Georgia Perakis

A growing number of strategies are being proposed to increase consumption of healthy food in low income food deserts. While there is agreement that food environments are linked to diet and health outcomes, there is surprisingly little agreement about the impact of certain interventions, due to a lack of understanding of the underlying mechanisms that influence household food choice. In this work we empirically evaluate the impact of access- and education-based interventions. We then use these findings to build a novel behavioral model of household grocery shopping, nested into a bi-level model to optimize government funding across price-, access-, and education-based interventions.

4 - Bike Sharing Systems - The Economic and Environmental Impact of Operational Strategies

Sanjith Gopalakrishnan, University of British Columbia, Vancouver, BC, V6T 1Z2, Canada, sanjith.gopalakrishnan@sauder.ubc.ca, Daniel Granot, Frieda Granot

Despite their growing popularity as a sustainable urban transport option, bike share programs in several cities such as Seattle and Montreal have run into financial difficulties due to low ridership and high operational costs. Further, their environmental benefits are ambiguous since a majority of users are substituting from public transport or walking. In this work, we adopt a consumer transport mode choice model and analyze the economic and environmental implications of three key operational levers: the pricing structure, station coverage and density, and frequency of rebalancing operations.

5 - Analytics-driven Inspection Operations for Failure Localization

Mathieu Dahan, Georgia Institute of Technology, Atlanta, GA, United States, mdahan@mit.edu, Steven B. Link, Saurabh Amin, Georgia Perakis

In this talk, we present a prescriptive analytics framework for localizing failures in the aftermath of a natural disaster. Given the diagnostic information provided by a failure prediction model, we consider a generic team orienteering problem with stochastic rewards and service times. We derive a compact mixed-integer programming formulation of the problem that computes an optimal a-priori routing of the inspection teams. Using the data collected by a major gas utility after an earthquake, we demonstrate the value of predictive analytics for improving their response operations.

■ TA55

CC- Skagit 4

Revenue Management and Marketplace Analytics II

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Kalyan Talluri, Imperial College Business School, London, SW7 2AZ, United Kingdom

1 - Dynamic Double Auctions: Toward First Best

Santiago Balseiro, Columbia University, New York, NY, 10027, United States, srb2155@columbia.edu, Vahab Mirrokni, Renato Paes Leme, Song Zuo

We study the problem of designing dynamic double auctions for two-sided markets in which a platform intermediates the trade between one seller and multiple buyers, repeatedly over a finite horizon, when agents have private values. Motivated by online platforms for advertising, ride-sharing, and freelancing markets, we seek to design mechanisms in which the platform never asks the seller to make payments nor are buyers ever paid and every agent derives a non-negative utility from every trade opportunity. We provide mechanisms satisfying these requirements that are asymptotically efficient and budget-balanced with high probability as the number of trading opportunities grows.

2 - Estimating Large-scale Tree Logit Models via a Difference of Strictly Convex Functions

Srikanth Jagabathula, NYU Stern School of Business, New York, NY, 10012, United States, sjagabat@stern.nyu.edu, Paat Rusmevichientong

We describe an efficient estimation method for large-scale tree logit models, using a novel change-of-variables transformation that allows us to express the negative log-likelihood as a difference of strictly convex functions. Exploiting this representation, we design a fast iterative method that computes a sequence of parameter estimates. No step size or second-order derivative is required. The sequence of parameter estimates yields increasing likelihood values, and we show that every limit point is a stationary point. Numerical results show that our algorithm outperforms state-of-the-art optimization methods, especially for large-scale tree logit models with thousands of nodes.

3 - Sourcing Strategies for Online Retail Marketplaces

Nikolay Osadchiy, Emory University, Atlanta, GA, 30322, United States, Sridhar Seshadri, Vishal Gaur, Marti Subrahmanyam

Motivated by empirics of price trajectories in online marketplaces, we study the inventory ordering problem under selling price and demand uncertainty. We show how price uncertainty changes the ordering pattern and how suppliers can benefit from offering time-flexible ordering policies to firms selling through online marketplaces.

4 - Revenue Management of a Professional Services Firm

Kalyan Talluri, Imperial College Business School, E, C/Ramon Trias Fargas 25-27, London, SW7 2AZ, United Kingdom, kalyan.talluri@imperial.ac.uk, Angelos Tsoukalas

The operations management of large professional service firms (law, accounting, medicine, investment banking, architecture, advertising, and consulting) has not been well studied despite their prominence in the service sector. The goal of this paper is to get insight into their revenue management operations and also develop optimization models to aid the partners in their bidding and matching process.

■ TA56

CC- Skagit 5

Business Applications

Contributed Session

Chair: Songrui Liu, S F Technology Co Ltd, Shenzhen Software Industry Base 1B, Shenzhen, 518061, China

1 - Game Review

Zheng Zhang, University of Tennessee, Knoxville, Knoxville, TN, United States, zzhan100@vols.utk.edu

Econometric and machine learning methods have been applied to financial performances predictions. However, asynchronous time series make analysis from classical theories cannot be applied directly. In this paper, we apply the traditional vector auto-regressive (VAR) model and weighted generalized elastic-net Granger (WEGEG) to forecast the financial indices based on predictors from social media and third-party platforms. We offer the financial institutions managerial suggestions when facing the negative evaluations from the Internet. Moreover, we find that WEGEG performs better the state-of-art method especially when the distribution of the data is hard to be identified.

2 - The Impact of Embedding Self Descriptive Information in Product Reviews

Arda Zuber, University of Connecticut-Storrs, Mansfield, CT, United States

In this study, we investigate the product category specific impact of reviewer credibility by examining the self-descriptive information disclosure present in the review text. Our results show that disclosure of different types of personal information does not have homogeneous effects across product categories, and revealing a certain type of self-descriptive information has varying effects on review helpfulness posted for products in different product categories.

3 - Exploring Hybrid Innovation Capabilities in Manufacturing

Yu-Yu Lu, National Cheng Kung University, Tainan City, Taiwan, Hsin-Hsin Chang

Providing service is a crucial issue for capital goods manufacturers. This study aims to explore firms with the capability of processing customer information through knowledge integration mechanism and absorptive capacity are able to improve their hybrid (product and service) innovation capability. Through case studies of Taiwanese equipment manufacturers, the preliminary result of this study indicates that firms who collect and identify the suitable customer information and transform them to useful firm knowledge are able to improve their incremental hybrid innovation capability, however, the radical hybrid innovation capability is hardly seen in the case companies.

4 - Cluster Analysis of the Relationship Between Logistics Performance Index and Economic Growth

Youqin Pan, Salem State University, Salem, MA, United States, ypan@salemstate.edu

This study applied cluster analysis to investigate the relationship between logistics performance index and economic growth. The findings demonstrate that variables such as logistics quality , infrastructure, tracking and tracing are drivers of cluster membership. Countries in different clusters may have different priorities in improving their logistics performance, which in turn may boost its national economy and help expand trade among trading partners.

5 - Automated Timetabling Framework

Songrui Liu, S.F. Technology Co., Ltd., Shenzhen, China, liusr228@outlook.com, Jing Wang

The time and computing complexity of timetabling rises exponentially as the size of realistic problems goes up. Thus an effective framework—ATF is proposed for convenience, consisting of six modules: shift design, staffing, duty scheduling, assignment, parameters tuning, and results adjustment. Each module of this framework is configurable based on personalized decomposition of problems. Objectives are also customized to maximize personnel utilization and enhance employee satisfaction. For solving, both Mixed Integer Programming model and heuristics algorithms are developed throughout the framework. In terms of applications, several modules of ATF have already been adopted in SF.

■ TA57

CC- Yakima 1

Joint Session PSOR/Practice Curated: Rapid-onset Disaster Operations Management

Sponsored: Public Sector OR

Sponsored Session

Chair: Mahyar Eftekhar

1 - Pre-positioning Disaster Relief Assets for Improved Rapid Response

Christopher Zobel, Virginia Tech, Blacksburg, VA, 24061-0235, United States, czobel@vt.edu, Andrew N. Arnette, Duygu Pamukcu

In this work, we build on our previous research with the Red Cross on developing a disaster relief asset pre-positioning model. The original model developed a risk function based on hazard likelihood, exposure, and vulnerability in order to pre-position assets for opening shelters in response to rapid onset disasters. Potential extensions being explored include the incorporation of weather information and advisories to improve shelter opening decisions, and the development of a two-stage stochastic programming model to extend the pre-positioning model into early stages of relief replenishment.

2 - Fleet Composition in Response to Natural Disasters and Armed Conflicts

Alfonso J. Pedraza-Martinez, Associate Professor, Indiana University Bloomington, Bloomington, IN, United States, alpedraz@indiana.edu

This study examines empirically the fleet composition of a large international humanitarian organization (HO) that responds to natural disasters and armed conflicts. We focus on understanding how the HO configures its fleet and specifically decides on renting or subcontracting transportation to deliver services to its beneficiaries. Transportation expenses are one of the largest expenses for the organization. We use thirteen-year panel data on transportation and personnel (local and expatriate) expenses of twenty-four country offices of this organization to build a fixed-effect model. We combine our proprietary data with publicly available data on natural disasters and armed conflicts.

3 - Preparing for Hurricane Preparation

Eva D. Regnier, Professor, Naval Postgraduate School, Monterey, CA, 93943, United States, eregnier@nps.edu, Cameron MacKenzie

The Hurricane Decision Simulator is an online training environment for US Marine Forces Reserve personnel to gain realistic experience making high-stakes dynamic decisions regarding costly preparation to protect safety, assets, and mission from a threatening hurricane. Working with US Marines at a headquarters facility in New Orleans and a small Reserve Training Center outside Miami, we have mapped their decision timelines, with costs and consequences, in preparation for an oncoming hurricane. We report on its use in practice, experimental results for a simplified scenario, and future directions.

4 - Supply Management for the Immediate Relief Period of Rapid-onset Disasters

Mahyar Eftekhar, Arizona State University, BA 433, Tempe, AZ, 85287, United States, eftekhar@asu.edu, Jing-Sheng Jeannette Song, Scott Webster

Focusing on the immediate relief period, we consider two common alternatives for both single and multiple items, in the presence of budget and local supply uncertainties. In this setting, due to many unknowns such as time, place, and magnitude of a disaster, supply management is a significant challenge. We define a model to determine the optimal prepo stock level assuming local purchasing is prioritized. We derive properties of the optimal solution, identify exact solution methods, and identify approximate methods that are easy to implement. We characterize the interplay of supply, demand, and budget uncertainties, as well as the impact of product characteristics on optimal prepo stock levels.

■ TA58

CC- Yakima 2

Data Driven Insights for Decision Making

Sponsored: Public Sector OR

Sponsored Session

Chair: Gabriela Gongora Svartzman, PhD Candidate, Stevens Institute of Technology, Hoboken, NJ, United States

1 - Urban Data Analytics to Analyze Quality of Experience in City Services

Gabriela Gongora Svartzman, PhD Candidate, Stevens Institute of Technology, Hoboken, NJ, United States, ggongora@stevens.edu, Jose Emmanuel Ramirez-Marquez

Research is rich in analyzing the quality of city services, while the quality of experience lacks exploration. Data mining of social media, natural language processing and urban analysis techniques are employed to measure the quality of experience in city services, by measuring the perception of customers towards a service. This work provides a framework to analyze how services react to different types of disruptions (e.g., weather) through time and their effect on customers. Two of these effects being social cohesion and resilience during disruptions The results are presented through visualizations and data analytics for decision makers.

2 - Extracting Decision-making Metrics from Text and Placing the Human Feedback in the Quantitative Loop

Carlo Lipizzi, PhD, Stevens Institute of Technology, Hoboken, NJ, 07030, United States, clipizzi@stevens.edu

Having tools to support decision taking has been a necessity since a while. When most of the available input is text, the challenge is to extract valuable metrics from the text, merging it with available numeric data, collect quantitative humans' input - for the ethic-centric components and for expert scoring - and provide proper visualizations.We present a method leveraging on a computational version of Marvin Minsky's framework theory and an application in a case study.

3 - Data Driven Insights for Cancer Diagnosis.

Shikha Soneji, Stevens Institute of Technology, Hoboken, NJ, 07030, United States, ssoneji@stevens.edu

Researchers have found that AI is able to detect cancer and other diseases earlier than possible through standard diagnostic methods, which could be lifesaving for future patients. The aim of this study is to measure the survival data of the 10 most common types of cancer cases in the world. This is achieved by using different journal and conference papers regarding cancer and its detection methods and the results obtained will help in analyzing them. These visualizations are different graphs developed using languages like Python and JavaScript for making it a dynamic interactive visualization, which would help the healthcare community to further diagnose these diseases in a faster way.

4 - Approximate Dynamic Programming for Bayesian Optimization with Multi-information Sources

Xubo Yue, University of Michigan, Ann Arbor, Ann Arbor, MI, 48105, United States, maxyxb@umich.edu

In this work, we consider a dynamic programming (DP) formulation for multiple information sources Bayesian optimization (BO). DP algorithm employs non-myopic (non-greedy) strategies to actively select sampling points and account for future information, allowing a balance between exploration and exploitation in BO and thus a better performance. Due to the large state space and the action space, we approximate DP using rollout, a sequential approach to optimization problem. Experiments on synthetic and real world data show that the proposed framework outperforms state-of-the art approaches.

5 - Exploratory Data Analysis to Recognize Vulnerable Groups for Human Trafficking

Nafisa Mahbub, University at Buffalo, Amherst, NY, United States, nmahbub@buffalo.edu, Jun Zhuang

Human Trafficking can be spotted as the most violated human rights among all the crimes. Examining the relational and functional properties of different types of crimes and illicit trade networks is essential to identify vulnerability (segments of the population targeted in terms of socio-economic factors, crime profile of a geographic location) of the group of people to either being involved or being victimized by the illicit trade networks. Novel data visualization, supervised and unsupervised machine learning techniques have been exploited here to identify different clusters based on similarities in crime profile.

6 - Mining the Topics for Budget Allocation in Group Decisions

Chen Wang, Tsinghua University, Tsinghua University, Beijing, 100084, China, chenwang@mail.tsinghua.edu.cn, Tanpisit Chen, Shenming Song

In group decision making, people express their preferences and try to influence the collective decision. This research proposes a text mining method to identify key topics of the conversation and the decisiveness of each topic in determining how much each player in a group obtains in a budget allocation scenario. We then characterize heterogeneity of players' capabilities and interactions based on a large number of simulation exercises completing the same allocation task.

■ TA58a

CC- Chelan 1

7:30-8:15 Automation Anywhere
8:15-9:00 Stukent

Vendor Tutorial

1 - Increasing Operational Efficiency with Automation Anywhere's Digital Workforce Platform

Amitai Jacobsen, Automation Anywhere, San Jose, CA, United States

The Automation Anywhere bot building tutorial is designed to showcase Robotic Process Automation (RPA), Cognitive Automation and Analytics tools that make up Automation Anywhere's Digital Workforce Platform. We will demonstrate the process of building digital workers, or bots, on our platform and within minutes. These bots can collect and analyze data and perform tasks that otherwise would be performed by humans, making processes more efficient, reducing errors and improving operational efficiency. The tutorial will feature Automation Anywhere Enterprise, IQ Bot, and Bot Insight and will show that these tools are not meant exclusively for engineers or IT experts but indeed also for business users. Participants will learn the process of creating bots, automating common processes and will have a chance to familiarize themselves with Automation Anywhere's software solutions.

2 - 16 Tips for Teaching a Marketing Analytics Course

Scott Yost, Stukent, Idaho Falls, ID, United States

Are you struggling to teach your marketing analytics course? In this session, Scott will share the top tips to teaching a more complete course including what platforms you should use, available resources, and the ways you can keep your course up-to-date.

■ TA59

CC- Chelan 2

Joint Session QSR/Energy: Statistical Learning for Energy Analytics

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Ahmed Aziz Ezzat, Rutgers University

Co-Chair: Hoon Hwangbo, University of Tennessee, Knoxville, TN, 37996-2315, United States

1 - Renewable Energy: The Forgotten Solutions

Andrew Kusiak, Professor, University of Iowa, Dept of Industrial and Systems Engineering, Iowa City, IA, 52242-1527, United States, andrew-kusiak@uiowa.edu

Generation of renewable energy has been steadily increasing, however, decades are needed to reach the clean footprint of energy. The developments in renewable energy over the last two decades have focused on increasing power of energy generators and construction of large-scale wind and solar farms. To accelerate deployment of renewable energy, innovation across the life-cycle of renewable energy is needed. Problems and solutions in the renewable energy chain awaiting research and development attention are addressed.

2 - The Calibrated Regime-switching Model for Wind Speed and Power Forecasting

Ahmed Aziz Ezzat, Rutgers University, New Brunswick, NJ, 77840, United States

We propose an advanced spatio-temporal statistical model, called the calibrated regime-switching model. The proposed model is designed to capture salient properties of wind fields: regime-switching dynamics, spatio-temporal dependencies, transport effect of wind, and nonstationarity. Tested on 11 months of hourly data from 200 wind turbines, double-digit improvements in the accuracy of wind speed and power forecasts are achieved relative to six widely used approaches in the literature.

3 - Wind Resource Assessment and Characterization at Non-observational Locations

Youngchan Jang, University of Michigan, Ann Arbor, MI, United States, mapsossa@umich.edu, Eunshin Byon

Selecting an appropriate wind farm site is one of the most important keys for ensuring the profitability of a wind farm. To this end, a thorough analysis of characterizing non-stationary and volatile features of wind conditions is critical. This study proposes a probabilistic spatio-temporal model for estimating wind speeds at potential sites where wind measurements are not unavailable. The proposed models are constructed using measurements collected from nearby meteorological stations, and day-to-day and station-to-station variations of wind speeds are quantified. The performance of the proposed approaches is evaluated using actual data collected in multiple meteorological stations.

4 - Data-driven Approach to Dynamic-var Compensator Placement for Voltage Stabilization on Feeders with High PV Penetration

Nader Samaan, Pacific Northwest National Laboratory PNNL, Richland, WA, United States, nader.samaan@pnnl.gov

Distribution feeders with a high penetration of distributed photovoltaic (PV) systems can experience voltage variability caused by the changing power flow injections corresponding to the availability of the solar resource. Dynamic Var Compensators (DVCs) can be used for local voltage stabilization. This presentation introduces a statistical framework to characterize voltage variability and stabilization, proposes a data-driven approach to DVC placement, and presents the results of a planning study on a real feeder using real data.

■ TA60

CC- Chelan 4

Panel Session for Industrial Data Science

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Abdallah A. Chehade, University of Michigan-Dearborn, Dearborn, MI, 48128, United States

Moderator

Abdallah A. Chehade, University of Michigan-Dearborn, 4901 Evergreen Road, 2280 HPEC, Dearborn, MI, 48128, United States

The goal of this session is to push the frontiers in industrial data science and its connection with academic research, which will be of great value to all the attendees including industry researchers, students, and academic faculty. The session provides a forum where participants can share their vision on current industrial data science opportunities, identify important problems and areas of application, explore emerging challenges, and formulate future research directions to enhance industry-academia relationship and development.

Panelists

- Xiaoshan Zhang, Facebook
- Chitta Ranjan, ProcessMiner Inc., Atlanta, GA, 30308, United States
- Houssam Nassif, Seattle, WA, United States
- Vivian Li, Director of Data Science, Astrum University, Kirkland, WA, United States

■ TA61

CC- Chelan 5

Advanced Data Analytics in Cyber Manufacturing Systems

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Xiaoyu Chen, Virginia Tech, Blacksburg, VA, 24060, United States

Co-Chair: Ran Jin, Virginia Tech, Blacksburg, VA, 24061, United States

1 - Model Selection Consistency of Penalized Likelihood Methods in Statistical Transfer Learning

Zhenli Song, HKUST, Hong Kong, Hong Kong, Fugee Tsung

Nowadays, automatic data acquisition is now frequently deployed in manufacturing and service applications. Consequently, many data generating processes have been activated, which require effective and efficient modeling procedures to analyze the data and estimate the unknown parameters. However, the data collected from lately activated processes are usually of high variability and low volume. Meanwhile, abundant data is usually available in the processes that have operated for a long time, some of which share similar statistical structure with the process of interest. In this paper, we investigate the model selection consistency property in the context of statistical transfer learning.

2 - Multi-response Adaptive Computation Pipelines via Clustered Low-rank Regularization in Cyber-manufacturing Computation Services

Xiaoyu Chen, PhD Candidate, Virginia Tech, Blacksburg, VA, 24060, United States, xiaoyuch@vt.edu, Lening Wang, Ran Jin

Existing adaptive computation pipeline method AdaPipe formulates a recommender system with single performance metric (i.e., accuracy) to match pipelines with contexts in a cyber-manufacturing system (CMS). However, recommendation based on single metric cannot satisfy multi-dimensional metrics (e.g., latency, redundancy), which are critical in a complex CMS. Simply adding dimensions will easily violate the low-rank assumption of AdaPipe and matrix completion models. Thus, we propose a multi-response adaptive pipelines by using clustered low-rank regularization to accurately match pipelines with contexts. An evaluation in a fiber CMS validates the proposed method.

3 - Matching Computation Pipelines with Contexts in Cyber-manufacturing Computation Services

Ran Jin, Virginia Tech, Blacksburg, VA, 24061, United States, jran5@vt.edu, Xiaoyu Chen

Cyber-manufacturing systems (CMS) will accelerate the transformation from offline modeling to online computation services, e.g., modeling and prediction. Various data analytical methods can be organized in sequences as computation pipelines. However, it is computationally challenging to identify the best one given different needs and contexts from many pipelines in a CMS. Thus, we formulate the selection of pipelines as a recommendation problem to rank and suggest the superior pipelines. A new extended matrix completion method is proposed to match computation pipelines and CMS contexts. An evaluation in 60 datasets and 27 pipelines validates the effectiveness of AdaPipe.

4 - Copula-based Multi-event Modeling and Prediction Using Fleet Service Records

Akash Deep, University of Wisconsin Madison, Madison, WI, 53703, United States, Shiyu Zhou, Dharmaraj Veeramani

Recent advances in information and communication technology are enabling availability to event sequence data from fleets comprising potentially a large number of similar units. We present a novel method for modeling and prediction of such event sequences using fleet service records. The proposed method uses Copula to create the joint distribution of time-to-event variables, where the marginals distributions needed for Copula are obtained through Cox PH regression models. Our method is flexible and efficient in modeling the relationships among multiple events compared to traditional methods.

5 - Decision Support System for Hybrid Additive Manufacturing Implementation

Michael G. Kay, North Carolina State University, Raleigh, NC, 27695, United States, Brandon McConnell, Guha Manogharan

Decision tradeoffs between performance and cost are not unique to the military, but consequences for failure differ. This work presents a decision support system for hybrid additive manufacturing (AM) logistics to address two key decisions: (1) whether to employ AM in a logistics network & (2) how to allocate AM capability within the network. The research establishes a methodology to address these decision points and identify the key tradeoffs between performance (e.g. readiness, lead time, production time, etc.) and costs (e.g. fixed/operating/logistics cost, etc.). Real production data of selected parts from a specific military portfolio is employed to evaluate the benefits of hybrid metal AM.

■ TA62

CC- Tahoma 1

Improving the Allocation of Donor Organs

Sponsored: Health Applications

Sponsored Session

Chair: Burhaneddin Sandikci, University of Chicago, Booth School of Business, Chicago, IL, United States

Co-Chair: Sait Tunc, University of Chicago, Booth School of Business, Chicago, IL, 60615, United States

1 - Treating to the Priority in Heart Transplantation

Sait Tunc, University of Chicago, Chicago, IL, 60615, United States, Burhaneddin Sandikci, Philipp Afeche, William F. Parker

US heart allocation system assigns priorities to waiting candidates based on the therapies they receive, where the severity of therapies used is assumed to measure the urgency of a candidate to receive a heart transplant. It is, however, constantly debated that therapy-based prioritization opens up room for gaming the system. Manipulation of the waitlist priority is even acknowledged by the medical community and there is an active debate on the issue. We propose a novel framework to analytically study the gaming decisions of heart transplant centers, understand when strategic gaming emerges under different competition types, and how it can be prevented within the confines of the current system.

2 - Karda: A Simulator for Kidney Acceptance Rejection Decisions

Masoud Barah, Northwestern University, University of Tennessee, Evanston, IL, United States, mbarah@northwestern.edu, Sanjay Mehrotra

Candidates for the deceased-donor kidneys are in a long waitlist before they are offered an organ. Once offered, a recipient and the physician have a short window to accept or reject the offer. We present a stochastic tree based kidney acceptance/rejection decision simulator to help facilitate the provisional offer acceptance decision making. The simulator incorporates future provisional offers of random quality, arriving at random times. It provides insights into the survival benefit of the current offer against simulated future provisional offers. Moreover, our engine computes a set of metrics that are useful for the patient and the physicians to make an informed decision.

3 - An Empirical Framework for Sequential Assignment: The Allocation of Deceased Donor Kidneys

Nikhil Agarwal, MIT Department of Economics, Cambridge, MA, 02142, United States, Itai Ashlagi, Michael A. Rees, Paulo Somaini, Daniel Waldinger

The theoretical trade-offs in designing waitlist offer systems depend on agent preferences. We propose an empirical framework for analyzing the waiting list for deceased donor kidneys. The model views the decision to accept an organ offer as an optimal stopping problem. Our estimates show that there is substantial match-specific heterogeneity in values. Past reforms to the kidney waitlist primarily resulted in redistribution, with similar welfare and organ discard rates as the benchmark first come first served mechanism. Other theoretical benchmarks also remain far from optimal: we design a mechanism that increases patient welfare by 14.2 percent.

4 - A Queueing Approach to Evaluate the Impact of Conditions of Participation on Organ Discards and Transplant Waiting List Mortality

Mohammad Delasay, Assistant Professor of Operations Management, Stony Brook University, NY, 11733, United States, mohammad.delasay@stonybrook.edu, Sridhar R. Tayur

We investigate waiting list management from the viewpoint of a transplant center in the presence of the conditions of participation (COP). COP penalizes centers with lower-than-expected post-transplant survivals. We model the waiting list as a multi-dimensional queue, which we analyze by proposing accurate truncation bounds of its state space. We show how an inappropriately assigned COP threshold for a transplant center without consideration of its specifications could induce cherry-picking of the candidates and offered organs. We discuss that COP lacks a net benefit approach by focusing only on post-transplant outcomes.

■ TA63

CC- Tahoma 2

Queues in Emergency Departments

Sponsored: Health Applications

Sponsored Session

Chair: Daniel Ding, UBC, Vancouver, BC, Canada

1 - Priority, Capacity Rationing, and Ambulance Diversion in Emergency Departments

Tianshu Lu, University of Toronto, Toronto, ON, M5S 3E6, Canada, Tianshu.Lu15@Rotman.Utoronto.Ca, Opher Baron, Jianfu Wang

Capacity rationing and ambulance diversion are two important practices in emergency department (ED) management. We model these practices as a two classes non-preemptive priority M/M/c+M queue where high- and low-priority customers correspond to acute and non-acute patients, respectively. We model capacity rationing by reserving k servers to high priority customers, and ambulance diversion by blocking high priority customers from entering the system when the total number of patients is high. We give the first exact results for a multi-server queue with non-preemptive priorities. Numerical results provide insights on the control of capacity rationing and ambulance diversion in EDs.

2 - Dynamic Server Assignment in Multiclass Queues with Shifts, with Application to Nurse Staffing in Emergency Departments

Vahid Sarhangian, University of Toronto, Mechanical and Industrial Engineering (MIE), Toronto, ON, M5S 3G8, Canada, sarhangian@mie.utoronto.ca, Carri Chan

Nurse staffing decisions in emergency departments (EDs) are typically assigned weeks in advance, which can create staffing imbalances as patient demand fluctuates. In this work, we consider the potential benefits of assigning nurses to different areas within an ED at the beginning of each shift. We study the problem of optimal reassignment of nurses to areas by considering a multiclass queueing model of the system. We analyze an associated fluid control problem and use the solution to develop policies that achieve asymptotically optimal performance under fluid-scaling for the original stochastic system. We find this additional flexibility can substantially reduce waiting times for patients.

3 - Wait Time Announcements at Emergency Departments

Marco Bijvank, University of Calgary, Calgary, AB, T2N 1N4, Canada, marco.bijvank@haskayne.ucalgary.ca, Zhankun Sun

Numerous hospitals have started publishing live emergency department (ED) wait times online in an effort to provide patients with expectations on how long they will have to wait to be seen for non-urgent care. The goal of this study is to accurately predict real-time ED wait times. We propose a decomposition approach of continuous-time Markov chains to calculate busy periods as predictor. The applicability and performance of each prediction technique is analyzed based on a case study of an ED in Calgary. Survey results show how announced wait times are used in practice, whereas the potential impact of the different prediction techniques on patient flow care are studied with a simulation model.

4 - Head-of-Line Delay Based Scheduling in Multiclass Queues with Applications to CTAS

Xu Sun, Assistant Professor, University of Florida, Gainsville, FL, United States, xs2235@columbia.edu, Yunan Liu

Motivated by the Canadian triage acuity scale (CTAS), we consider a delay-based prioritization policy for a multi-class queueing system having time-varying arrivals, with the objective of achieving differentiated service levels for all customer class. Specifically, CTAS classifies patients in Canadian EDs into 5 acuity levels, ranging from “resuscitation” (level 1) to “non-urgent” (level 5), with delay targets ranging from 0 to 120 mins and probability of excessive delay ranging from 2% to 20%. Motivated by CTAS, our policy guarantees that each customer class is served with a quality-of-service target based on the tail probability of delay with class-dependent delay and probability targets.

■ TA64

CC- Tahoma 3

Aged Care Analytics: Models, Methods and Applications

Sponsored: Health Applications

Sponsored Session

Chair: Nan Kong, Purdue University, West Lafayette, IN, 47906-2032, United States

Co-Chair: Mingyang Li, Tampa, FL, 33647, United States

1 - Nursing Home Staffing Decision Support Platform under Heterogeneous and Temporally Evolving Service Demands of Residents

Xuxue Sun, University of South Florida, Tampa, FL, United States, Nan Kong, Hongdao Meng, Kathryn Hyer, Chris Masterson, Mingyang Li

Nursing homes (NHs) are critical healthcare infrastructures for caring frail older adults with 24/7 formal care and personal assistance. Adequate staffing is of great importance to ensure quality of care and desired resident outcomes. Existing healthcare staffing literatures mainly assume homogenous and/or static service demands of patients. This work proposes a NH staffing decision support platform by characterizing heterogeneous, temporally evolving service demands of NH residents via novel integration of statistical modeling, computer simulation and optimization techniques. A case study is also provided to demonstrate the superior performance of the proposed work.

2 - Explainable Learning for Disease Risk Prediction Based on Comorbidity Networks

Qingpeng Zhang, City University of Hong Kong, Kowloon, 12180, Hong Kong, qingpeng.zhang@cityu.edu.hk, Zhongzhi Xu

In this paper, we propose a comorbidity network involved end-to-end trained disease risk prediction model. The adoption of side information and the end-to-end framework together assign both high accuracy and transparency to the model. To demonstrate the prediction performances of the proposed model, a real case study based on three years’ medical histories from the Hong Kong Hospital Authority is considered. Results show that the proposed model exhibits superior prediction performance while learns explainable rules.

3 - Diagnosis of Cardiac Diseases via Higher Order Hidden Markov Model: Application to Personalized Biomedical Radar Data

Ying Liao, Texas Tech University, Lubbock, TX, United States, Yisha Xiang, Changzhi Li

Analysis of heartbeat signals is critical to provide information for the diagnosis of cardiac diseases, e.g., beat detection, segmentation and classification based on electrocardiogram (ECG) signals. Since the ECG data collection requires medical assistance, recently, a new personalized biomedical radar has been devised, which can monitor long-term continuous heartbeat signals. This research applies a higher order hidden Markov model (HOHMM) to identify heartbeat patterns utilizing the collected data, which extends the basic hidden Markov model (HMM) by allowing the hidden health state to depend on its more distant past.

4 - Discharge Control in Congested Nursing Homes Using Markov Decision Process

Zhouyang Lou, Purdue University, West Lafayette, IN, 47904, United States, zlou@purdue.edu, Nan Kong

With the aging population, we are facing a spike in demand for nursing home care. However, nursing homes will experience the insufficient capacity issue due to workforce shortage and resource to community care. Imbalanced supply and demand will lead to congestion in nursing homes and hospitals. To improve patient flow into nursing homes, we consider the problem of finding an optimal discharge policy using Markov decision processes to minimize the wait time taken to be admitted and the rehospitalization risk. We will analyze the benefits as opposed to the situation with no discharge control for different supply and demand scenarios.

5 - Opioid Prescription Optimization Model for Total Joint Replacement Surgery Patients

Sujee Lee, University of Wisconsin-Madison, Madison, WI, 53705, United States, slee776@wisc.edu, Philip A. Bain, Jingshan Li

Opioid overdose has become a public health hazard in the United States. One of the reasons for overdose is over-prescription in hospitals to treat chronic and acute pain. The current guidance in opioid prescription often takes one-size-fits-all prescription approach and rarely considers differences between patients. In this talk, we propose an optimization model that simultaneously classifies patients based on their profiles and opioid use patterns and minimizes remaining opioids to reduce the opioid over-prescription and overdose for total joint replacement surgery patients.

■ TA65

CC- Tahoma 4

Matrix Estimation, Multi-armed Bandits, and Healthcare Applications

Sponsored: Health Applications

Sponsored Session

Chair: Mohsen Bayati, Stanford University, Stanford, CA, 94305, United States

1 - Matrix Completion Methods for Causal Panel Data Models

Khashayar Khosravi, Stanford University, Stanford, CA, 94305, United States, khosravi@stanford.edu, Susan Athey, Mohsen Bayati, Nikolay Doudchenko, Guido Imbens

A central tool in empirical operations management is the average treatment effect (ATE) estimation from observational data. In this setting, the presence of potential confounders leads to biased estimates of ATE. One way to reduce this bias is to use panel data models where a subset of units is exposed to a binary treatment during some time-periods and the goal is estimating the counterfactual outcomes for all treated units/time-period pairs. We study a class of estimators that minimize the distance between the estimated matrix and the original matrix while favoring less complex models. We prove the consistency of our estimators by extending the existing results in the matrix completion literature.

2 - Matrix Completion Bandit with Healthcare Applications

Carolyn Kim, Stanford University, Stanford, CA, 94305, United States, Mohsen Bayati

We introduce a matrix completion formulation of the multi-armed bandit problem, where we observe some subset of entries of columns that arrive over time and we wish to impute the rest of the entries. This can be used to model the decision-making process of a physician whose chooses lab tests to maximize the information gained from the results while satisfying a budget constraint. We adapt the proof of classical matrix completion results to our bandit setting to show a sublinear regret bound. Experimentally, we demonstrate our strategy performs well against a number of baseline strategies.

3 - Active Synthetic Control

Ruoxuan Xiong, Stanford University, Huang Building Stanford, CA, 94305, United States, rxiong@stanford.edu, Mohsen Bayati, Susan Athey, Guido Imbens

In clustered randomized trials (CRT), experiments are randomized at the group level instead of the individual level to avoid contamination. For example, in a trial comparing different weight-loss programs, patients may meet each other in the waiting room and communicate about their respective strategies. But randomization at the provider level, would reduce the risk of contamination. However, CRTs suffer from low statistical power. In this talk, we combine ideas from synthetic control and active learning to design CRTs that can significantly increase statistical power.

4 - Phase Transitions and Cyclic Phenomena in Bandits with Switching Constraints

Yunzong Xu, Massachusetts Institute of Technology, Cambridge, MA, 02139, United States, David Simchi-Levi

We consider the classical stochastic multi-armed bandit problem with a constraint on the total cost incurred by switching between actions. We prove matching upper and lower bounds on regret and provide near-optimal algorithms for this problem. Surprisingly, we discover phase transitions and cyclic phenomena of the optimal regret. That is, we show that associated with the multi-armed bandit problem, there are phases defined by the number of arms and switching costs, where the regret upper and lower bounds in each phase remain the same and drop significantly between phases. The results contribute new insights to this fundamental problem.

5 - Personalizing Many Decisions with High-dimensional Covariates

Nima Hamidi, Stanford University, Stanford, CA, United States

We consider the k-armed stochastic contextual bandit problem with d dimensional features, when both k and d can be large. To the best of our knowledge, all existing algorithm for this problem have a regret bound that scale as polynomials of degree at least two in k and d. The main contribution of this paper is to introduce and theoretically analyse a new algorithm (REAL-bandit) with a regret that scales by $r^2(k+d)$ when r is rank of the $k\times d$ matrix of unknown parameters. REAL-bandit relies on ideas from low-rank matrix estimation literature and a new row-enhancement subroutine that yields sharper bounds for estimating each row of the parameter matrix that may be of independent interest.

■ TA66

CC- Tahoma 5

Personalized Medicine III

Emerging Topic: Personalized Health

Emerging Topic Session

Chair: Dimitris Bertsimas, Massachusetts Institute of Technology, Cambridge, MA, 02139, United States

1 - Machine Learning Approaches for Stroke

Agni Orfanoudaki, Massachusetts Institute of Technology, Cambridge, MA, 02142, United States, agniorf@mit.edu, Dimitris Bertsimas, Charlene Ong, Amre Nouh, Rebecca Zhang

Modern machine learning methods can leverage data from both observational studies and Electronic Health Records to create personalized risk prediction models. In this talk we will present our work on the development of interpretable non-linear tools for primary stroke prediction as well as natural language processing techniques for the detection of presence, location and acuity of ischemic stroke. We provide a comprehensive framework for structured and unstructured data in the medical setting that can be leveraged in wide range of medical applications.

2 - A Network-based Approach to Drug-target Interactions in Cancer

Holly Mika Wiberg, Massachusetts Institute of Technology, Cambridge, MA, 02144, United States, hwiberg@mit.edu, Dimitris Bertsimas, Agni Orfanoudaki

We propose a novel graph-based optimization approach to modeling gene regulatory networks for the purpose of understanding gene interactions and pathway function in the presence of mutations. We use a maximum flow formulation to evaluate pathway disruption which provides biological insight into the optimal drug targets for a given mutation profile. Empirical results suggest that this approach recovers biologically valid relationships between genes. We extend the work by Bertsimas and Zhuo to incorporate this structured pathway model and demonstrate recovery of new drug-target interactions.

3 - Tensor Completion with Noisy Side Information

Colin Pawlowski, Massachusetts Institute of Technology, Cambridge, MA, United States, Dimitris Bertsimas

We develop a new method for tensor completion which incorporates noisy side information available on the rows and columns of a 3-dimensional tensor. This method learns a low rank representation of the data along with regression coefficients for the observed noisy features. We apply this method to the task of predicting anti-cancer drug response at particular dosages, and we demonstrate significant gains in out-of-sample accuracy filling in missing values on two large-scale anti-cancer drug screening data sets with genomic side information.

4 - Optimal Trees for Estimating Risk of Mortality and Morbidity in Elective Surgery Patients

Katerina Giannoutsou, Massachusetts Institute of Technology, Boston, MA, United States, giannoutsou.kat@gmail.com, Dimitris Bertsimas

Most risk assessment tools assume that the impact of risk factors is linear and cumulative. Using data from The American College of Surgeons National Surgical Quality Improvement Program's database and utilising Optimal Classification Trees (OCT), a novel machine learning technique that combines high accuracy with interpretability, we designed an interactive, non-linear risk calculator to predict postoperative mortality as well as 18 specific complications for patients undergoing four different types of Elective Surgery

5 - Will They Stay or Will They Go? Anticipating Patient Discharges with Machine Learning

Jean Pauphilet, Massachusetts Institute of Technology, Cambridge, MA, United States, jpauph@mit.edu, Dimitris Bertsimas

We investigate how machine learning can provide precise information about patient discharges at a major hospital using data from EHRs. Combining expertise-driven modeling and data analysis tools, we predict with high accuracy (a) daily discharge volume, (b) long-stay patients, (c) discharge destination, (d) administrative delays to discharge. The predictions are made at a patient level, updated daily and currently used to improve daily operations. In this effort, tree-based methods were instrumental because of their interpretability and ability to deal with missing data.

■ TA67

S- Virginia

Simulation Analysis and Methods I

Sponsored: Simulation

Sponsored Session

Chair: Chang-Han Rhee, Northwestern University, Chicago, IL, 60613, United States

1 - Rapid Search with Gaussian Markov Improvement Algorithm

Eunhye Song, Penn State University, University Park, PA, 16802, United States, eus358@psu.edu, Mark Semelhago, Barry L. Nelson, Andreas Waechter

We introduce rapid-Gaussian Markov Improvement Algorithm (r-GMIA) that models the objective function over a large discrete solution space as a realization of a Gaussian Markov random field. r-GMIA alternates between rapid search and global search phases to balance computational efficiency and search effectiveness using complete expected improvement (CEI) as the sampling guide. At a global search iteration, a set of promising solutions is constructed. During the rapid search iterations, we restrict CEI computations and sampling decisions within the set. Per-iteration computational cost of rapid search phase is negligible compared to that of a global phase resulting a faster search progress.

2 - On the Stability of Kernelized Control Functionals on Partial and Biased Stochastic Inputs

Haofeng Zhang, Columbia University, New York, NY, United States, hz2553@columbia.edu, Henry Lam

We investigate some theoretical properties of kernelized control functionals (CFs), a recent technique for variance reduction, regarding its stability when applied to subsets of input distributions or biased generating distributions. This technique can be viewed as a highly efficient control variate obtained by carefully choosing a function of the input variates inside a reproducing kernel Hilbert space. We show that CFs retain good theoretical properties and lead to variance reduction in some contexts relevant to large-scale stochastic simulation analysis. We also compare these properties with importance sampling, particularly a related type using a similar kernelized approach.

3 - Rare-event Simulation for Gibbs Measures: Properties and Applications of the Infinite Swapping Algorithm

Pierre Nyquist, KTH Royal Institute of Technology, Stockholm, Sweden, pierren@kth.se

Rare-event sampling is a hindrance to efficiently sampling from Gibbs measures, especially in the settings of high dimension or ``low temperature”, where the prevalence of local minima causes slow convergence. Infinite swapping is a Monte Carlo method designed to overcome the problem of rare-event sampling in the setting of computing integrals with respect to Gibbs measures. This talk will focus on properties of infinite swapping and (non-standard) applications - quantum dynamics, machine learning - and the use of empirical measure large deviations and ergodic control problems to study convergence rates for MCMC methods. The talk is based on joint work with Dupuis, Doll, Hult and Ringqvist.

4 - Importance Sampling for General Levy Processes with Heavy-tailed Increments

Chang-Han Rhee, Northwestern University, Chicago, IL, 60613, United States, chang-han.rhee@northwestern.edu, Xingyu Wang

Chen et al. (2019) proposed a strongly efficient rare-event simulation algorithm for a broad class of rare events associated with heavy-tailed random walks and compound Poisson processes. In this talk, we discuss how one can extend the rare-event simulation algorithms in Chen et al. (2019) to deal with general Levy processes.

■ TA68

S- University

Joint Session Sharing Econ & Crowdsourcing/Practice Curated: OR&OM in e-commerce

Emerging Topic: Sharing Economy & Crowdsourcing

Emerging Topic Session

Chair: Huan Xu, ISyE Ga Tech, Atlanta, GA, 30332, United States

1 - Distributionally Robust Omnichannel Stocking Decisions in Quick-Fulfillment Systems

Hanzhang Qin, Massachusetts Institute of Technology, Cambridge, MA, 02142, United States, hqin@mit.edu, Louis L. Chen, David Simchi-Levi, Huan Xu, Zirun Zhang

This work is inspired by the daily operations of Alibaba’s HEMA supermarket, which manages multiple demand channels (offline, online, etc.). We study how to make a stocking decision for a SKU in advance of uncertain demand arising in several consecutive time frames that is robust to an adversarial coupling of available (marginal) demand distributions by channel and by time frame. We provide both an efficient procedure and analytical characterization of the adversary’s coupling. While the full problem is non-convex, we identify sufficient conditions for convexity, along with a tractable algorithm. Finally, we conduct experiments with HEMA data to evaluate the performance of our approach.

2 - Contextual Linear Bandit under High-dimensional Data via Lasso and Random Projection

Tao Yao, Alibaba, 349 Leonhard Building, Seattle, PA, 16803, United States, taoyao2005@gmail.com

In the era of big data, products’ contextual information is widely available and has accumulated with extraordinary speed. The resulting high- dimensional feature data, however, leads to two major challenges in implementing contextual bandit algorithms in online settings: The poor estimation of high-dimensional feature coefficients with access to limited samples and the high computational time complexity. We propose a contextual linear bandit algorithm under high-dimensional data, the Lasso-RP-Bandit algorithm, by combining the Lasso and random projection to alleviate the computational complexity and ensure its regret performance.

3 - Traffic Shaping – Online Learning and Optimization in E-commerce

Nan Li, Alibaba Group, Hangzhou, China, nanli.ln@alibaba-inc.com

In traffic shaping, a collection of sessions arrive in an online manner, and within each session, we need to make optimal decisions such that immediate reward is maximized while certain constraints over the entire sessions are satisfied. In practice, the constraints can be business operation strategies, this problem has found applications in online businesses. In this talk, we will talk about our recent developments in traffic shaping, including the framework, algorithms, systems. Also, we will share some applications of traffic shaping in e-commerce.

4 - Large-scale Time Series Anomaly Detection via Robust Decomposition

Liang Sun, Alibaba Group, Bellevue, WA, United States, liang.sun@alibaba-inc.com

The exponential increase of streaming data calls for more efficient and low-latency analytics. Anomaly detection, which identifies unusual patterns from data, is crucial in many applications. In this talk, we introduce an anomaly detection framework based on decomposition for time series data. Compared with the widely used forecasting-based anomaly detection algorithms, our method is robust to noisy data and outliers. Our framework can detect different types of anomalies, including spikes and dips, change of mean, change of variance, and long-term monotonic trend. Our experiments on real-world benchmark datasets demonstrate the effectiveness and efficiency of our method. applications.

5 - Optimal Sequencing of Heterogeneous, Non-instantaneous Interventions

Kai He, Alibaba Inc, Bellevue, WA, United States, kai.he@alibaba-inc.com, Oleg A. Prokopyev, Lisa M. Maillart

Consider a stochastically deteriorating system that generates reward at a rate that depends on its condition. There are three heterogeneous interventions/actions that can be performed. Two of these are one-time interventions, each of which is either ineffective or effective with some known probability after a specific delay period. The third intervention is palliative in nature, and has no effectiveness delay. To maximize the total expected reward, we examine the problem of optimally sequencing these interventions to simultaneously balance three inherent trade-offs: the time until (potential) effectiveness is revealed, probability of effectiveness, and cost.

6 - Secondary Market Mitigates Demand Uncertainty

Jian Lou, Kirkland, WA, 98033, United States

In this paper, we study how a free-trading secondary market could mitigate players’ demand uncertainty in the primary market. We consider the following setting: a resource manager is allocating resources to some autonomous players with uncertain demands. These players report their orders to the manager, pay, and receive requested resources before the demands have been realized. These players also have stipenalties for failing to subsequently fulfill the demand, which creates incentives for players to over-request the resources. However, the resulting behavior by individuals imposes unnecessary costs on the system. As a means to mitigate this issue, we introduce a secondary market that allows players to trade resources after demand uncertainty has been resolved. To analyze the impact of the secondary market on the player resources requesting behavior, we model the setting as a two-stage game, with the first stage identical to the newsvendor model, and the secondary market taking place in the second stage. We mainly consider a large market, which we analyze asymptotically as the number of players n tends to infinity. We find that an individual’s inuence on the price in the secondary market is O(1/sqrt(n)) and the expected price in equilibrium in the secondary market is equal to the price in the primary market as the number of players approaches innity. Signicantly, we find that the social welfare is within O(sqrt(n) of optimal, in contrast to a game with no secondary market, which exhibits Theta(n) difference to the optimum.

■ TA69

S- Seneca

Sports Analytics V

Contributed Session

Chair: Stephen Hill, University of North Carolina-Wilmington, Wilmington, NC, 28403-5611, United States

1 - Consistent Probability Assignments in Two Player Contests with Maximum Entropy

Christopher Gaffney, Drexel University, Philadelphia, PA, United States, ctg39@drexel.edu

We consider the problem of determining probabilities in contests involving two players. We assume that each player's overall winning percentage is known and that the players have had at least some common opponents. A nonlinear programming model is used to determine, for each pair of players, the probability that one defeats the other. The constraints correspond to various consistency needs of the ensuing probability assignments, while the objective is to maximize the entropy of the probability distributions resulting from the problem.

2 - Predicting Injuries Through the Use of Force Plate and Strength and Conditioning History

Kiatikun Louis Luangkesorn, Assistant Professor, University of Pittsburgh, Pittsburgh, PA, United States, lluangkesorn@pitt.edu, Yiqi Verna Tian, Yuezhe Wendy Wang, Tharunkumar Amirthalingam

The goal of a university strength and conditioning program is to minimize the risk of injury for student-athletes while improving athletic performance for the athlete's sport. The is accomplished through individually programming exercises using multiple modalities and variety. We use both the force plate assessments over time as well as the athlete's strength and conditioning programming history as inputs to a predictive model to predict injury risk for student-athletes, with the goal of using the model to motivate assessments by coaches to prevent the injury from occurring.

3 - Normalization Strategies and Development for Improved NCAA Basketball Tournament Predictions

Jessica M. Rudd, PhD Candidate, Kennesaw State University, Kennesaw, GA, United States, jess@irudd.com

The study utilizes various normalization techniques for NCAA basketball tournament prediction. Baseline models using tournament seeds, several popular sports ranking methods, regular season game statistics, and tournament results, dating back to 1985 where available, are compared with results using several normalization strategies, including approaches not known to be tested on this problem as well as a novel season rank-based approach. Baseline models predicted previous tournament wins with accuracy as high as 76%. Normalized model brackets performed as high as 97% accuracy in the 2019 tournament.

4 - Probabilistic Models Focusing on the Scoring Order in a Sports Match

Kengo Hamada, Keio University, Yokohama, Japan, kengo.hamada@keio.jp, Ken-ichi Tanaka

Sports matches have been subjected to extensive mathematical analyses, and most previous studies have focused mainly on match outcomes (e.g., the final score or win-loss records). On the other hand, as a new attempt, we focus on the process up to that: scoring order in which two competing teams score as the match progresses. For example, we formulate the probability of the favorite team falling behind the opposing team but then making a comeback, which is introduced based on lattice path enumeration. We also present some variants and extensions of the proposed model.

5 - Planning for a New Soccer Stadium: A Real Options Approach

Carlos Abreu, Federal University of Rio Grande do Norte State (UFRN), Natal, Brazil, calexandreabreu@ect.ufrn.br

Real Options valuation models are used in financial analysis in scenarios with high uncertainty. This decade has been important in the development of new soccer stadiums for Brazilian clubs. The decision-making on the construction of sports arenas have an elevated uncertainty due to the uncertain impacts on game day future revenues. Using Real Options with the proper forecasting data on expected revenues and prices permits the estimation of an optimal investment return considering the expectation created on fans regarding the new arena and its effects on the clubs revenues.

■ TA70

S- Jefferson A

Social Media, Network Analytics and Crowdsourcing

Sponsored: EBusiness

Sponsored Session

Chair: Qian Tang, Singapore Management University, Singapore, 178902, Singapore

1 - Wisdom of Crowds and IPO Hype Cycle

Alvin Leung, Assistant Professor, City University of Hong Kong, Hong Kong, acmleung@cityu.edu.hk

This paper investigates when wisdom of the crowds fails on social media. When information becomes one-sided and online users tend to follow the crowds, investors are likely to be herded and stock price is likely to experience abrupt change. By observing online chatters, we may observe whether such phenomenon occurs. Analyzing over 10-year data of 1000 IPO stocks from StockTwits, we find that we can foreshadow the occurrence of failure of wisdom of crowds from social networks and online chatters. We can make use of the data to predict the IPO hype cycles. Our study has important implications to existing literature on social media and stock returns predictions.

2 - An Empirical Examination of Cryptocurrency and Online Peer-to-peer Lending Markets

Keong Tae Kim, Chinese University of Hong Kong, Shatin, Hong Kong, keongkim@cuhk.edu.hk, Sunghun Chung, Chulho Lee

We study the effect of cryptocurrency markets on borrowers in peer-to-peer (P2P) lending markets. By using the combined data from both markets during the period January 2017 to February 2019, we provide several novel findings. Our results indicate that the growth in cryptocurrency markets is associated with a large amount of loan requests in the P2P market. This complementarity is strong for borrowers who have good credit grades and are likely to have further knowledge of and might use the borrowed money for investing in the cryptocurrency market. Furthermore, the growth in cryptocurrency markets is not associated with a decrease in the loan quality.

3 - Social Comparison and Social Fitness Network Evolution

Ben Choi, Nanyang Technological University, Singapore, Singapore

Social fitness apps have become a cost-effective way to promote regular physical activity. This research proposal intends to draw on the social comparison theory to investigate the longitudinal usage of social fitness apps. We posit that similarity and dissimilarity in exercise performance between a user and others will influence the likelihood of forming new social connections, maintaining existing social ties, and user's subsequent exercise performance. To operationalize the study, we constructed a panel data using a popular social fitness app. Exponential random graph model and latent growth model were constructed to analyze the data.

4 - Software Development Kit Network and Mobile App Success

Yu Xia, The University of Hong Kong, Hong Kong, yuxia0230@gmail.com, Chen Hailiang

The adoption of third-party Software Development Kits (SDKs) in mobile app development is becoming increasingly popular. While the impact of SDKs on app success has not been well examined. This study aims to quantify the effect of SDK adoption on mobile app performance and in particular focuses on the role of SDK network. Our dataset covers all mobile apps released on both Apple App Store and Google Play from 2008 to 2018. Mobile app performance is measured by the number of app downloads and revenues. We use the number of apps that install two SDKs at the same time to denote the strength of the SDKs' connection. Our findings would help app developers better understand the role of SDKs in mobile app development.

5 - Ladies First, Gentlemen Third! The Effect of Narrative Perspective on Medical Crowdfunding

Xitong Li, Associate Professor, HEC Paris, 1 rue de la Liberation, 78351, France, lix@hec.fr

In practice, a majority of medical fundraising campaigns are narrated from the third-person perspective without knowing whether it is the most effective approach or not. We propose that the relative effectiveness of the first- vs. third-person perspective depends on patient gender. To test the hypotheses, we conduct a randomized field experiment on a leading medical crowdfunding platform, involving more than 1.2 million potential donors. The results show that the third-person perspective is more effective in motivating donation-related behaviors for male-patient fundraising campaigns, whereas the first-person perspective is more effective for female-patient fundraising campaigns.

■ TA71

S- Jefferson B

Behavioral Aspects in Humanitarian Operations, Non-profits and Public Policy

Sponsored: Behavioral Operations Management

Sponsored Session

Chair: Pelin Pekgun, University of South Carolina, Columbia, SC, 29205, United States

1 - Modeling Human Decisions in a Dynamically Coupled Natural and Human Systems Framework to Develop Freshwater Sustainability Policies

Jessica L. Heier Stamm, Kansas State University, Manhattan, KS, 66503, United States, jlhs@k-state.edu, Gabriel Granco, Jason S. Bergtold, Matthew R. Sanderson, Marcellus M. Caldas, Steven M. Ramsey

Culture is an important factor influencing human decisions about freshwater conservation policies. Despite this, most human decision models embedded in coupled natural and human system frameworks adopt a purely economic approach. We describe an agent-based simulation model that employs the values-beliefs-norms socio-psychological theory to represent stakeholders' decisions to support sustainability policies based on explicit feedbacks between humans and their environment. The model is applied to the Smoky Hill River Watershed in the U.S. Great Plains, where it enables insights about freshwater sustainability policies and their impacts on the coupled systems.

2 - Mechanism of Donation in Humanitarian Sector

Mahyar Eftekhar, Arizona State University, Tempe, AZ, 85287, United States, eftekhar@asu.edu, Iman Parsa, Charles J. Corbett

Humanitarian organizations (HOs) rely heavily on donations. Using a panel data from over 100 US-based HOs between 2000 and 2014, we examine the impact of fundraising investment, program spending ratio, transparency, media exposure, and program diversity on humanitarians' donation income. Based on the existing theories, we illustrate what mechanism of donation is dominant in this sector, and whether or not humanitarian organizations can adopt policies to increase their income.

3 - The Impact of Service Level on Inventory Decisions

Sebastian Villa, University of Los Andes, Cra. Bogota, Colombia, s.villab@uniandes.edu.co, Jaime Andres Castaneda, Gloria Urrea

We study the fundamental tradeoff in inventory management between inventory costs and service level to satisfy customers. This tradeoff is critical in settings like humanitarian operations, in which failing to provide a high service level could mean the loss of lives. We derive the optimal policy using a newsvendor framework, imposing a service level and the cost associated with filling this target if running out of stock. We next design an experiment to study how subjects place orders in a high-profit inventory task, varying understock costs and service levels. Compared with low service levels, results show that high service levels lead to improved orders when understock costs do not exceed revenues.

4 - Analyzing Drivers Behind Food Waste in Food Banks

Fan Zou, University of South Carolina, Columbia, SC, United States, Fan.Zou@grad.moore.sc.edu, Luv Sharma, Pelin Pekgun, Sanjay L. Ahire

This study identified factors contributing to food waste in food banks and operational decisions that can reduce waste.

■ TA72

S- Columbia

Business Transformation in the Age of Analytics

Sponsored: Information Systems

Sponsored Session

Chair: Ling Xue, Georgia State University, Atlanta, GA, 30302, United States

1 - Regulating Professional Player in Peer-to-peer Markets: Evidence from AirBnB

Wei Chen, University of Arizona, Tucson, AZ, 85718, United States, weichen@email.arizona.edu, Zaiyan Wei, Karen Xie

The influx of "professional players"—large companies or powerful individuals—in peer-to-peer (P2P) platforms has been widely documented. Yet the impacts of these professional players and whether platforms should regulate their participation are largely unanswered. Utilizing a unique policy change on Airbnb, we evaluate the role of professional players on market structure and transaction efficiency in peer-to-peer markets. We find that restricting institutionalized players leads to mitigation in market concentration. Consequently, it increases consumer welfare by lowering the equilibrium price and improving service quality.

2 - An Empirical Analysis of User Satisfaction with Chatbots

Ling Xue, Georgia State University, Department of Computer Information Systems, J. Mack Robinson College of Business, Atlanta, GA, 30302, United States, Cheng Zhang, Xia Zhao

The use of AI-enabled customer service systems is often associated with risks and uncertain customer satisfaction. In this study, we use operational level data of customer service chatbots to develop insights about how chatbots may affect both the productivity of human customer support representatives and the satisfaction of individual customer. Our findings suggest that while the use of chatbots may not necessarily increase the overall efficiency of the customer service process, it can effectively reduce the burden for human representatives. Also, we find that while more experienced customers are more likely to report declined satisfaction possibly because of their higher expectations.

3 - Disentangling the Effect of Longitudinal Consumer Reviews on Professional Service

Hongfei Li, School of Business, University of Connecticut, Storrs, CT, United States, hongfei.Li@uconn.edu, Jing Peng, Gang Wang, Xue Bai

Online diaries are series of posts generated by consumers in chronological order to record their post-consumption experience over time. This paper empirically investigates whether providing follow-ups in online diaries affects the sales of professional services, and how this impact is moderated by the perceived risk and the quality of service. We find that providing follow-ups has a positive effect on the sales. The effect is weaker for high-quality service. Interestingly, this effect is asymmetric for service with high and low perceived risks. Our findings provide important implications for both platform owners and service providers.

■ TA73

S- Boren

Optimization Applications in Engineering and Industry

Sponsored: INFORMS Section on Practice

Sponsored Session

Chair: Aristotelis E. Thanos, GE Global Research Center, Glenville, NY, 12302, United States

1 - Activity Assignment and Routing of Field Personnel in Zillow Offers Business

Suleyman Karabuk, Zillow, Seattle, WA, 98109, United States

Zillow Offers business buys and sells homes as a service. An acquired home is renovated before it is put on the market under the Zillow brand name. Each renovation is managed by an assigned Superintendent (SI), who visits a home several times during the process. On a daily basis Zillow routes a team of SIs to visit homes subject to time window constraints. These decisions are constrained by the prior assignment of homes to SIs. We solve a combined multi-day assignment and one-day routing problem, which compared to manual decision making saves thousands of miles per month.

2 - Workforce Deployment Planning in GE Healthcare

Nitish Umang, GE Global e deployment in a GE healthcare application.

Please check the mobile app for this abstract.

3 - Prescriptive Decision Support for GE Fleet, Maintenance, Repair and Overhaul

Aristotelis E. Thanos, GE Global Research Center, 408 Reserve Cr, Glenville, NY, 12302, United States

We present a prescriptive analytic platform for decision support in the GE aviation industry targeting to reduce jet engine lease cost and aircrafts on ground for our customers. Our platform targets both optimal decision for managing aircraft fleet and capacity optimization in our overhaul shops.

■ TA74

S- Capitol Hill

Location Analysis II

Sponsored: Location Analysis

Sponsored Session

Chair: Pawel J. Kalczynski, California State University-Fullerton, Fullerton, CA, 92834-6848, United States

Co-Chair: Zvi Drezner, California State University-Fullerton, Fullerton, CA, 92834, United States

1 - Self Organized Carpools with Hubs

Malgorzata Miklas-Kalczynska, California State University-Fullerton, Fullerton, CA, 92834-6848, United States, mmiklas-kalczynska@fullerton.edu, Pawel J. Kalczynski

We incorporate optional hubs into two types of carpooling problems. We provide a theoretical analysis of neighborhoods for problems with and without hubs and use the findings to formulate enumeration models. We test the new models on simulated problem instances using a decentralized self-organization heuristic and a centralized optimization algorithm. Our findings show that introducing hubs increases carpool participation and produces savings. We demonstrate that self-organized carpools, which maximize individual savings, are comparable with centralized solutions, optimized for system-wide savings. Additional savings from hubs depend on the type of the carpooling problem.

2 - Multiple Obnoxious Facilities Location: A Cooperative Model

Pawel J. Kalczynski, California State University-Fullerton, Fullerton, CA, 92834-6848, United States, PKalczynski@fullerton.edu, Zvi Drezner, Tammy Drezner

A given number of communities exist in an area. Several obnoxious facilities, such as polluting factories need to be located in the area. The nuisance emitted by the facilities is cumulative. The objective is to minimize the nuisance inflicted on the most affected community. This problem is useful for planners who frequently face this problem of locating obnoxious facilities and have no good way to determine a good set of locations for these facilities. A multi-start approach by the SNOPT and IPOPT solvers in Matlab gave poor results. However, an innovative, specially designed Voronoi based heuristic produced much better results in a small fraction of the run time.

3 - Computational Results for Solving the Euclidean Distance Min-max Location Problem with Fixed Distances in N-dimensions Using a Dual Algorithm

Mark Cawood, Senior Lecturer, Clemson University, Clemson, SC, 29634-0975, United States, cawood@clemson.edu, Lin Dearing

Computational results for the dual algorithm are presented for the problem, also called the minimum covering Euclidean ball of a set of Euclidean balls in n-dimensions. The algorithm searches along a directed path that is a ray, a hyperbola, or an ellipse. The step size is computed explicitly at each iteration.

4 - Maximal Covering Location with Ellipses

Sergio Garcia Quiles, University of Edinburgh, School of Mathematics, James Clerk Maxwell Bldg, King's Building, Edinburgh, EH9 3FD, United Kingdom, sergio.garcia-quiles@ed.ac.uk, Victor Blanco

In a covering location problem there is a set of demand points and a set of potential sites for locating facilities. A point is covered by a facility only if it is within a certain distance from the facility. These problems have applications in areas like the location of emergency services or nature reserve selection. In the Maximal Covering Location Problem introduced in the 1970s, a fixed number of facilities must be located so that the amount of covered demand is maximized. The geometric shapes used to cover the demand points are circles. Motivated by applications to Wireless telecommunications networks, in this talk we will present a variant of this problem where the covering shapes are ellipses.

■ TA75

S- Metropolitan Ballroom A

Flash Session I

Flash Session

Chair: Iris Moryossef, Hadassah Academic College, Harel 99740, Jerusalem, 99740, Israel

1 - Religious and Consumer Behavior of the First Time Mother

Iris Moryossef, Senior Lecture, Hadassah Academic College, Jerusalem, Israel, rsgernter@gmail.com

Among the features including in the culture of the consumer effecting its consumer behavior, religious is one of the most powerful factors (Shukor, & Jamal 2013). Religious as a part of culture is a dramatic feature that takes place during transition in the life cycle of the person including motherhood Motherhood is a major transition in the women's life were the changes are physical, emotional and behavioral. The mother to come is changing her consumption decision process, information collection and brand evaluation (Gertner 2014) In this article we will examine the culture of new mothers in the religious Orthodoxy culture in Israel and its implication.

2 - A Branch-and-price Algorithm for the Integrated Production Scheduling and Delivery Routing Problem with a Product

Peiyang He, Huazhong University of Science & Technology, WuHan, China

In this paper we study the integrated production scheduling and delivery routing problem, which is NP-hard in the strong sense. In the production stage, the manufacturer has to produce a set of products on a single machine with constant production rate. In the distribution stage, there are a given number of homogeneous vehicles with limited capacity. The objective is to minimize the sum of waiting time of all customers. We propose a new set-covering formulation and present a branch-and-price algorithm for solving this problem. The computation results show that, the proposed formulation and algorithm are efficient.

3 - A Classification Algorithm Based on Consumer Segmentation for Online Purchase Forecast

Xinxin Ren, Huazhong University of Science and Technology, Wuhan, China, renxinxin@hust.edu.cn, Xianhao Xu

In the era of big data, lots of historical consumption data can be used to predict consumers' purchase behavior and target marketing. However, low active consumers are prevalent in the online market, each of them generates several action records and rarely purchase. So, there is larger amount of negative data (no purchase) that may cause imbalance data and have adverse effect for prediction. Therefore, we propose a hybrid algorithm where we segment consumers into low active and high active segments, then establish predictive models for each segment. Finally, we compared the performance of proposed model with the benchmarks, and the result indicates that the performance is improved.

4 - A Conceptual Framework for Calculating the Return on Investment for Continuous Improvement

Mahmoud Al-Odeh, Bemidji State University, Bemidji, MN, United States, malodeh@bemidjistate.edu

The methodology of calculating the return on investment (ROI) of continuous improvement (CI) activities will be explained. The framework consists of three segments, which will be connected to financial factors. The presenter will show the use of the cost and benefits factors and convert them into factors to measure the effectiveness of CI activities. Different strategies for calculating ROI for CI will be discussed. The audience will be provided with specific factors and excel templets to conduct the ROI analysis. This framework is used to track the financial aspects of process improvements and organizations use it to improve their returns on investment. Cases will be shared with the audience.

5 - A Framework for Analyzing the U.S. Coin Supply Chain

Yiwei Huang, Pennsylvania State University, Sharon, PA, United States, yuh201@psu.edu, Yunxia Zhu, Subodha Kumar, Bala Shetty, Chelliah Sriskandarajah

We study a coin supply chain problem to provide a near-optimal or an optimal operating policy that minimizes the total cost of producing, supplying, and managing coin inventory in the U.S. Coin Supply Chain. The extensive tools and insights developed in this study may prove to be beneficial to the Federal Reserve's Cash Product Office (CPO) that manages the distribution of the nation's coin inventory. The robust optimization framework and the resulting insights presented in this paper could potentially help the CPO to manage demand uncertainty and achieve its cost reduction goals. The paper demonstrates a modeling approach that can also be used for managing similar coin supply chains around the world.

6 - Reducing Preventable Hospital Readmissions for Long Term Care

Emily Garcia, University of California-Berkeley, Berkeley, CA, United States, emilygarcia1216@berkeley.edu

We present an approach to determine risk factors and utilization costs associated with hospital admissions and readmissions originating from long-term care (LTC) facilities for post-acute care. Indiana Medicaid and Minimum Data Set data were used in the analysis. The risk model was used in the development of a discharge support tool in order to reduce unnecessary LTC readmissions.

7 - A Flow-Based Network Robustness Metric

Mohammad Najarian, University of Houston, Houston, TX, United States, mohammad.najarian@gmail.com, Gino J. Lim

Resilience of a single commodity network flow can be improved by increasing the capacity of components and improving the topology of the network. Several studies characterized the key elements in a robust network using the centrality measures. In this study we introduce a new flow- based centrality measure that and a novel functional connectivity matrix that can be used to design a more resilient network against cascading failure.

8 - A New Cluster Validity Index in Feature Space

Changwan Ko, Chonnam National University, Gwangju, Korea, Republic of, kcw7536@naver.com, Youngseon Jeong

This paper proposes a new cluster validity index(CVI) in which the compactness and separation of a cluster is measured in the kernel space by using kernel functions to overcome the noise sensitivity for arbitrary shapes, sub-clusters, and noise in data. The proposed CVI is evaluated through a series of experiments and shows that the proposed method can successfully determine the correct cluster number for most cases.

■ TA76

S- Metropolitan Ballroom B

Operations Management III

Contributed Session

Chair: Gulsah Hancerliogullari Koksalmis, Istanbul Technical University, Macka Campus Faculty of Management, Department of Industrial Engineering, Istanbul, 34367, Turkey

1 - Hotel Room Assignment Optimization

Andrew Vakhutinsky, Oracle Labs, Burlington, MA, United States, andrew.vakhutinsky@oracle.com, Setareh Borjian Boroujeni

We describe our work on hotel room assignment for the given set of room reservations made for different room categories. In order to alleviate the overbooking in the basic categories, the hotel operator may upgrade the rooms for more valuable guests. In addition, each room may have its own features that should match the guest preferences as close as possible. We formulate the hotel room assignment problem as multicommodity flow problem with integer variables and compare various solution approaches including Lagrangian relaxation and Dantzig-Wolfe decomposition using the real hotel booking data. We also share the lessons learned from implementing the optimization methods in the production system.

2 - Set Asides for Small Businesses in Public Procurement: Evidence from Federal Government Research & Development Contracts

Dwaipayan Roy, University of Minnesota, Minneapolis, MN, United States, Anant Mishra, Kingshuk K. Sinha

Preference programs in public procurement encourage the participation of specific types of contractors in the government contracting process. However, such programs may not always lead to the selection of the most qualified contractor to execute a contract. We examine the performance outcomes of R&D contracts that have been awarded preferentially to small businesses by the U.S. federal government. We also investigate how contractor experience and contract type influence the relationship between a contract’s set aside status and its performance outcomes. Study findings offer insights on how the federal government can simultaneously accomplish its welfare and efficiency maximization goals.

3 - An Effective Matheuristic for the New Large-scale Task Assignment Problem

Haichao Liu, Northwestern Polytechnical University, Xi’an, China, z929880965@126.com, Yang Wang, Haibo Wang, Abraham P. Punnen

We propose a three-stage matheuristic to solve a new task assignment model with the significantly increased number of variables and constraints. The initial phase decomposes the problem into a sequence of sub-problems, each of which is solved by GUROBI to quickly obtain a feasible solution. The intensification stage repeats performing variable fixation and MIP model solving until a local optimum is reached. The diversification phase solves such a modified model that adds a distance component into the objective. Experimental comparisons with GUROBI indicate that the proposed matheuristic is able to obtain better solutions, where the computational time is reduced by an order of magnitude.

4 - Should We Wait Before Outsourcing? Analysis of a Revenue-generating Blended Contact Center

Benjamin Legros, EM Normandie, Paris, France, benjamin.legros@centraliens.net, Oualid Jouini, Ger Koole

We consider a revenue-generating call center with inbound and outbound calls, where service and sales activities are blended. Two levels of control are exercised; agent reservation for inbound calls and call outsourcing. We consider an optimal control problem for maximizing the call center’s revenue. We investigate the strategy of outsourcing customers who have waited already, as opposed to outsourcing at arrival. We prove that the optimal policy for reservation and outsourcing is of threshold type. Our main conclusion is that outsourcing customers after letting them wait in-house generates higher revenue than outsourcing calls at arrival. However, it is also detrimental to service quality.

5 - Factors Influencing the Adoption of Bitcoin: An Empirical Study in the United States

Gulsah Hancerliogullari Koksalmis, Istanbul Technical University, Istanbul, Turkey, ghancerliogullari@itu.edu.tr

The aim of this research is to investigate and incorporate variety of factors affecting people’ behavioral intention to use Bitcoin. The technology acceptance model (TAM) and the perceived risk theory (PRT) were integrated to propose a theoretical model. The data was collected from the participants at the North American Bitcoin Conference, a part of “World Blockchain Forum: Investments & ICOs” which took place in the United States, in January 2018. The implications of the outcomes are discussed, and suggestions for future research are made.

■ TA77

S- Fremont

Scheduling I

Contributed Session

Chair: Thomas Lavastida, Carnegie Mellon University, Pittsburgh, PA, 15232, United States

1 - A Two-Stage Fast Heuristic for Food Delivery Route Planning Problem

Huanyu Zheng, Meituan-Dianping Group, Beijing, China, zhenghuanyu@meituan.com, Shengyao Wang, Ying Cha, Feng Guo, Jinghua Hao, Renqing He, Zhizhao Sun

Online food-delivery platforms are expanding choice, allowing customers to order from a wide variety of restaurants. As an industrial level technology, route planning algorithm is required to be fast enough. This paper proposes a two-stage fast heuristic for route planning, which solves the problem at millisecond level. To speed up the algorithm, we further utilize geographic information so that invalid search attempts are prevented. Finally, we compare our algorithm with brute-force algorithm and several state-of-the-art algorithms to show its effectiveness and efficiency.

2 - Scheduling Trucks at a Cross-docking Facility Using Parallel Evolutionary Algorithms: A Delayed Start Concept

Maxim A. Dulebenets, Florida A&M University-Florida State University, Tallahassee, FL, United States, mdlbnets@gmail.com

Cross-docking facilities have been widely used in supply chains. This study aims to enhance scheduling of the arriving trucks at a cross-docking facility and proposes a Delayed Start Parallel Evolutionary Algorithm. The algorithm launches separate Evolutionary Algorithms on its islands sequentially and exchanges the good-quality solutions among the active islands based on certain adaptive migration criterion. The numerical experiments demonstrate superiority of the proposed algorithm in terms of the major algorithmic performance indicators against the alternative metaheuristic algorithms.

3 - Supply Chain Scheduling with Fixed Time Interval Supplies

Guohua Wan, Shanghai Jiao Tong University, Shanghai, China, ghwan@sjtu.edu.cn, Xueqi Wu

We consider a supply chain scheduling problem with fixed time interval supplies, where the materials/components for production are only supplied at fixed delivery dates. The objective is to minimize the sum of job flowtime (representing work-in inventory) so as to minimize the inventory holding costs. We develop a branch and pricing algorithm to solve the problem, employing various techniques to speed up the solution process and conduct comprehensive computational experiments to test the performance of the algorithm. The computational results show that our algorithm can solve the problem with reasonable size to optimality in short times.

4 - Development of Scheduling Algorithms for a Crowdsourced Delivery Persons

Juntaek Hong, POSTECH, Pohang, Korea, Republic of, Myungho Lee, Kyungduk Moon, Kangbok Lee

In last decades, e-commerce has changed the logistics environment into much more competitive and time critical. Furthermore, as people want to have grocery or food to their doors in daily bases, demands for local delivery service has also increased. A service provider of crowdsourced delivery system wants to find an incentive mechanism or an operational policy to manage revenue and expand their business. Prior to the decision, they should understand how delivery persons would actually behave when demand and incentive are disclosed. This study suggests a mathematical model for the delivery person’s scheduling problem that optimizes their own profit under crowdsourcing environment.

5 - Online Load Balancing via Learned Weights

Thomas Lavastida, Carnegie Mellon University, Pittsburgh, PA, United States, tlavasti@andrew.cmu.edu, Silvio Lattanzi, Benjamin Moseley, Sergei Vassilvitskii

The use of machine learning and predictive models have produced a revolution in science and engineering. Online optimization problems are a natural source of uncertainty that predictions can be used to manage and improve performance. This paper studies how predictive techniques can be used to break through worst case barriers in online scheduling. The make-span minimization problem on unrelated machines and its special case, restricted assignment, are classic problems in online scheduling theory. In this paper we construct non-trivial predictions for these problems and design algorithms that utilize these predictions to compute solutions online.

■ TA78

S- Greenwood

Applications in DEA

Emerging Topic: Productivity, Efficiency and Data Envelopment Analysis

Emerging Topic Session

Chair: Ole Bent Olesen, University of Southern Denmark, Odense, 5230, Denmark

1 - Benchmarking and Regulation of Electricity Network Companies - Scale Assumptions and Potential for Strategic Mergers

Endre Bjorndal, NHH Norwegian School of Economics, Bergen, Norway, endre.bjorndal@nhh.no, Guanqing Wang, Terje Vassdal, Mette Bjorndal

Electricity network operators are natural monopolies and therefore often regulated. An example is the yardstick regulation model used by the Norwegian regulator, based on DEA-CRS benchmarking. Agrell & Teusch (2016) show that mergers between peers can change the comparison set for inefficient companies to their advantage, and companies may therefore pursue cost-increasing mergers that decrease social welfare. We discuss how alternative scale assumptions in the benchmarking model will influence the potential for such "peer" effects. We use data for Norwegian electricity distribution companies to illustrate our discussion.

2 - Incentives for Optimal Scale in the Regulation of Electricity Distribution Companies

Guanqing Wang, UiT The Arctic University of Norway, Tromsø, Norway, Endre Bjørnda

Electricity network companies are natural monopolies and are therefore often under regulation. An example is Norway, where yardstick regulation combined with data envelopment analysis (DEA) has been applied since 2007. The regulator's choice of scale assumption in the benchmarking model, e.g., constant returns to scale, will affect the network companies' incentives for structural reform. We discuss how alternative scale assumptions would affect the companies and their customers. We study how the relative profitability of companies in different size classes, as well as network charges for their customers, would be affected. Our discussion is based on data of Norwegian distribution companies.

3 - A Review of the Use of DEA in Accounting

Julie Harrison, University of Auckland, Department of Accounting & Finance, Auckland, 1142, New Zealand, j.harrison@auckland.ac.nz, Lily Chen, Fred Ng, Paul Rouse

DEA has become increasingly popular with accounting researchers and has been used to examine a range of issues, including audit firm productivity and the benchmarking of company performance using DEA. This paper critically reviews the accounting DEA literature to identify how and why DEA is used to answer accounting, as distinct from economic, research questions. The paper evaluates the constructs used and variables chosen and identifies potential application issues.

4 - Developing a Conceptual Foundation for 'Financial DEA'

Claire Cui, University of Aukland, Aukland, New Zealand, J ulie Harrison, Fred Ng

Recent years have seen the emergence of research measuring aspects of firm performance using 'Financial DEA', that is, models that only incorporate financial data. However, DEA conventionally uses physical data to measure productivity, underpinned by economics productivity theory. This study uses a summarised structured literature review and simulated data to examine (1) conceptual aspects of firm performance measured by 'Financial DEA'; and (2) methodological issues in 'Financial DEA' application.

■ TA79

S- Issaquah A

Joint Session Agriculture/Practice Curated: Uncovering Opportunities: How the Syngenta Crop Challenge Sparked Innovation in Agriculture

Emerging Topic: Agriculture

Emerging Topic Session

Chair: Greg Doonan, Syngenta, Slater, IA, 50244, United States

1 - Syngenta Crop Challenge and its Impact

Greg Doonan, Syngenta, Slater, IA, 50244, United States

Syngenta and the Analytics Society of INFORMS partnered in 2015 to launch the Syngenta Crop Challenge. Now in its fifth year, the Syngenta Crop Challenge in Analytics has brought awareness and excitement to the challenges and needs within agriculture. The agriculture industry delivers the world's food supply and by collaborating with INFORMS we have been able to engage the analytics community to identify new inter-disciplinary ways to tackle the challenges of feeding a growing population sustainably. Listen to past finalists discuss their work, what the competition has meant to them and their organizations and how their work has driven innovation in agriculture.

2 - Hierarchical Modeling of Seed Variety Yields and Decision Making for Future Planting Plans

Huaiyang Zhong, Stanford University, Stanford, CA, 94305, United States, hzhong34@stanford.edu

Eradicating hunger and malnutrition is a key development goal of the twenty first century. This paper addresses the problem of optimally identifying seed varieties to reliably increase crop yield within a risk-sensitive decision-making framework. Specifically, a novel hierarchical machine learning mechanism for predicting crop yield (the yield of different seed varieties of the same crop) is introduced.

3 - Novel Research Directions at Biosense Institute Sparked by Syngenta Crop Challenge

Oskar Marko, BioSense Institute, Novi Sad, Serbia, oskar.marko@biosense.rs, Sanja Brdar, Gordan Mimic, Marko Pani, Milica Brkic, Vladimir Crnojevic

BioSense Institute has a continuity of participation in Syngenta Crop Challenge, where we won the 1st prize in 2017 with an innovative solution for the optimal distribution of seeds across the American Midwest and came 4th and 3rd in 2016 and 2019. Based on the datasets provided by Syngenta we developed advanced machine learning algorithms for yield prediction, seed selection, characterisation of maize hybrids and model explanation. The challenge allowed us to better understand the practical problems that farmers, breeders and retailers are facing and to see how state-of-the-art technology can be employed for their solution.

4 - Combining Expert Knowledge and Neural Networks to Model Environmental Stresses in Agriculture

Jannis Schuecker, Fraunhofer Gesellschaft, IAIS, Sankt Augustin, Germany

Despite the great successes of machine learning, it can have its limits when dealing with insufficient training data. A potential solution is to incorporate additional knowledge into the training process which leads to the idea of informed machine learning. Based on an extensive research survey we establish a taxonomy that considers the kind of additional knowledge, its representation, and its integration into the machine learning pipeline. We use this methodology to combine agricultural expert-knowledge with representation learning capabilities of neural networks to model environmental heat and drought stress. This approach allows us to identify resistant corn hybrids.

■ TA80

S- Issaquah B

Collaboration in Innovation and New Ventures

Sponsored: Technology, Innovation Management & Entrepreneurship

Sponsored Session

Chair: Joel Wooten, University of South Carolina, Columbia, SC, 29208, United States

Co-Chair: Necati Tereyagoglu, University of South Carolina, Columbia, SC, 30308, United States

1 - Incentivizing Knowledge Creation in Innovation Contests

Sanjiv Erat, University of California-San Diego, Rady Sch Mgmt Otterson Hall, La Jolla, CA, 92093-0553, United States, Lakshminarayana Nittala

Knowledge created in the process of conducting their current innovation activities is often cumulative, and enables firms to gain greater value in their future endeavors. Still, the difficulty in measuring knowledge makes it much more common to solely incentivize the output. The current talk shall offer a formal model where individual employees engage in knowledge creation ("learning") and/or knowledge utilization ("doing"), and shall examine how the firm's relative value from employee learning and doing is affected by the incentives.

2 - Entrepreneurial Market Research: Theory and Experiments

Evgeny Kagan, Johns Hopkins University, Carey Business School, Baltimore, MD, United States, Stephen Leider, William S. Lovejoy

This work studies the effectiveness of different search policies for a variant of the bandit model, revised to account for features of the entrepreneurial market research process.

3 - How Do Entrepreneurs Who Fail Find Success

Pek-Hooi Soh, Professor, Simon Fraser University, Beedie School of Business, Vancouver, BC, V6C 1W6, Canada, psa28@sfu.ca, Wenwei Zhang, Wenhong Zhao

We study how entrepreneurs who recover from failures draw on past venturing experience and better prepare a new venture for success. Our SEM results show that an entrepreneur's setback experience from past ventures directly affects a venture's commitment to learning and indirectly via a positive attitude towards failure. Moreover, the impact of setback experience on attitude is reduced for entrepreneurs who gain more information access via industry ties. An entrepreneur's attitude towards failure is a good predictor of venture learning so long as it is not interfered by extraneous information.

4 - Overview of Collaboration in Innovation and New Ventures

Joel Wooten, University of South Carolina, Columbia, SC, 29208, United States, joel.wooten@moore.sc.edu

We set the stage for this session by giving an overview of collaboration, how it has been studied, and how the papers presented in the session fit into this topic.

■ TA81

S- Kirkland

Chemical and Petrochemical Applications

Sponsored: Energy, Natural Res & the Environment/Natural Resources Petrochemicals

Sponsored Session

Chair: Dimitri Papageorgiou, ExxonMobil Research & Engineering, Annandale, NJ, 08886, United States

Chair: Lois Kamga-Ngameni, University of Colorado, CO, United States

1 - Experimental Study of Non-Darcy Flow in a Proppant Pack Using Nitrogen Gas under High Pressure

Lois Kamga-Ngameni, CO, United States

Historically, Darcy's equation has been used to predict hydrocarbon production over a year-long time horizon. Unfortunately, this equation is not able to accurately predict the production of hydrocarbon in unconventional reservoirs. We present the Barree-Conway model (2004), which is valid for high gas rate and unconventional reservoirs while considering parameters that pertain to fluid flow at high Reynolds numbers.

2 - Incorporating Process Variables and Categorical Responses in Mixture Experiments

Mona Khoddam, Arizona State University, Tempe, AZ, United States, mkhoddam@asu.edu

Chemical and Pharmaceutical industries utilize mixture experiments widely where the levels of the experimental factors are varying proportions of several chemical components that sum to a 100%. Sometimes the response in hand is measured as a categorical variable, instead of a numeric, continuous one so we need and special type of modeling. Besides, some process variables, factors which are not mixture components but affect the blending properties of the mixture ingredients, are playing role in our experiment as well and this makes modeling and analysis more complicated.In this work, we discuss such an application.

3 - Process Control Optimization of Multistage and Multiresponse Production

Kihyuk Yoon, Ulsan National Institute of Science and Technology (UNIST), Ulsan, Korea, Republic of, Hojin Cho, Chiehyeon Lim, Junghye Lee

Companies attempt optimization of their production process control with newly available data. We optimized the control of a chemical product production process with real data by developing and combining different prediction and optimization models. The process involves multi stages and responses (quality characteristics) that affect the yield. Our models contribute to the factory to increase the yield and make more profit (approximately 1 million USD per year). In this presentation, we focus on the unique characteristics of our models that relfect the theoretical characteristics of multistage-and-multiresponse production problem and the empirical characteristics of available data.

4 - Dynamic Location and Relocation of Modular Manufacturing Facilities

Qi Zhang, University of Minnesota, Minneapolis, MN, United States, Andrew Allman

In the chemical industry, there is an emerging trend toward building manufacturing facilities consisting of modules that can be constructed off-site and then shipped to the site locations where they are assembled into whole functional production plants. These plants can significantly increase the ability of a supply chain to react to changes in demand. This work addresses the dynamic location and relocation of such facilities. We introduce a new MIP model for the problem and develop a tailored branch-and-price algorithm to solve large instances. Through various case studies, we provide insights into the value of module mobility and demonstrate the effectiveness of the proposed solution algorithm.

■ TA82

S- Leschi

Smart City Sustainability Aspects

Sponsored: Energy, Natural Res & the Environment/Environment & Sustainability

Sponsored Session

Chair: Victoria C. P. Chen, The University of Texas at Arlington, Arlington, TX, 76019-0017, United States

1 - Bounds for Optimal Control of a Real-time Multi-agent Demand Response System

Alireza Fallahi, PhD Candidate, University of Texas at Arlington, Arlington, TX, 76013, United States, Jay Michael Rosenberger, Victoria C. P. Chen

In stochastic programming (SP), a wait-and-see solution is at least as good as an optimal policy. On the other hand, a policy that uses the expected value problem is never as good as an optimal policy. This is well established in SP when there is a single agent. A question arises whether bounds exist when we have two agents. The present study develops a research methodology to answer this question. Our experiments show that if we have two separate agents, and both agents get perfect information, this can be worse compared to both agents doing the mean value problem. Nevertheless, we have found that there are bounds when the first stage follows the same set of actions. A two-agent demand response problem has been used as a case study to show this claim.

2 - Optimizing Water Supply Through Reservoir Conversion and Storage of Return Flow- A Case Study at Joe Pool Lake

Srividya Sekar, The University of Texas at Arlington, Arlington, TX, United States, srividya.sekar@mavs.uta.edu, Victoria C.P. Chen, Jay Michael Rosenberger, Glenn Clingenpeel, Yu Zhang, Amin Daghighi

Maintaining adequate water supply is one of the key challenges faced by the Dallas-Fort Worth Metroplex. In this study, UTA collaborated with Trinity River Authority (TRA), in conducting an exploratory study of the possibility of converting flood storage in Joe Pool Lake (JPL) to improve reliability of water supply and cost efficiency. It employs a linear programming (LP) approach that factors in the costs, revenues, demand/supply scenarios over the Trinity River Basin and the waste water treatment facilities of TRA. Given the inputs, the LP yields an optimal expansion of JPL and associated storage-diversion strategy on an annual basis.

3 - Crowd Logistics for Regional Food Systems

Narjes Sadeghiamirshahidi, University of Texas at Arlington, Arlington, TX, 76019, United States, narjes.sadeghiamirshah@mavs.uta.edu

Regional food systems have the potential to improve food supply chain sustainability. However, small-scale farmers struggle with cost-effective transportation and distribution. Direct sales via farmers' markets are inefficient and do not scale well, and distributors are too expensive and inflexible. One potential alternative is the use of crowd logistics, in which a decentralized network of potential transportation providers (the "crowd") is connected to customers seeking logistics services via a software platform. This research describes an agent-based model that was designed to study the potential of crowd logistics to improve transportation in regional food systems.

4 - Two Stage Stochastic Model for Enhancing Seismic Resilience of Water Pipe Networks

Azam Boskabadi, PhD Candidate, University of Texas at Arlington, Arlington, TX, United States, azam.boskabadi@mavs.uta.edu, Jay Michael Rosenberger, Mohsen Shahandashti, Binaya Pudasaini

Earthquakes may cause substantial damage to regional water pipe systems. Consequently, utility managers may rehabilitate pipes to limit damage in future disasters. In this research, we develop a nonlinear two-stage stochastic program to maximize post-disaster serviceability after an earthquake. We develop an approximate piecewise linear formulation and a reformulation-linearization technique. We discuss scenario generation and provide computational experiments.

■ TA83

S- Medina

Market Design for Sustainable Energy Systems

Sponsored: Energy, Natural Res & the Environment/Electricity Sponsored Session

Chair: Yue Zhao, NY, United States

1 - On the Market Equilibria of Renewable Power Producers in Congestion-constrained Power Networks

Yue Zhao, Stony Brook University, Stony Brook, NY, 11794, United States, yue.zhao.2@stonybrook.edu, Hossein Khazaei, Andy Sun

A two-settlement power market mechanism in which both conventional generators and renewable power producers (RPPs) participate is studied. A key advantage of the mechanism is that the independent system operator (ISO) does not need to consider the renewable's uncertainty when solving the economic dispatch problems in congestion-constrained power networks. The locational marginal prices at both stages are used for paying the RPPs. Under this market mechanism, an efficient method for computing the Nash Equilibrium among the strategic price-making RPPs is developed. Conditions under which the market equilibrium approaches the social optimum are developed and demonstrated in simulations.

2 - Electricity Pricing under Uncertainty via Chance Constraints

Yury Dvorkin, New York University, Metrotech Center, Fay Street, Brooklyn, NY, 11201, United States, dvorkin@nyu.edu

This presentation describes a stochastic electricity market design based on the use of chance constraints for modeling uncertain injections of renewable generation resources. The proposed design makes it possible internalize the effect of uncertainty within the price formation process, while considering technical limits on transmission network operations (e.g. ac power flow and voltage limits). We prove that the proposed market design yields a robust competitive equilibrium and can accommodate a variety of probabilistic assumptions on the underlying uncertainty. Our numerical simulations demonstrate the usefulness of the proposed market design on large-scale test systems.

3 - Mobile Storage for Demand Charge Reduction

Junjie Qin, UC Berkeley, Berkeley, CA, 94306, United States, qinj@berkeley.edu, Kameshwar Poolla, Pravin Varaiya

EV batteries, an increasingly prominent type of energy resources, are largely underutilized. This paper proposes a new business model that monetizes underutilized EV batteries to significantly reduce the demand charge portion of many commercial and industrial electricity users' electricity bills. This business requires minimal hardware to enable discharging batteries of electric vehicles and a sharing platform that matches EVs to commercial electricity users in real time. Using real meter data, we establish the financial viability of the business by studying the temporal distribution of user requests. We then discuss user-side and platform-side challenges for implementing this business.

4 - Demystifying Transactive Energy System: Glossary, Principle & Application

Jianming Lian, Pacific Northwest National Laboratory, 902 Battelle Blvd, Richland, WA, 99352, United States, jianming.lian@pnnl.gov

Transactive Energy System (TES) has gained great interests in the Power and Energy community. TES optimizes the operation of distributed energy resources through market-based transactions between participants. The underlying transactive control incorporates the economic concepts and principles into the decision making and controller design of individual market participants. It shares the advantages of both direct load control and price responsive control. However, as a newly emerging concept, it is still kind of mysterious to the research community. In this presentation, TES will be introduced from there aspects of technical glossary, theoretical principle and practical application.

5 - Dimensioning Operating Reserves in Multi-Cycle Processes

Miguel Ortega-Vazquez, Electric Power Research Institute, Palo Alto, CA, 94304, United States, Erik Ela

As the penetration of renewable generation deepens in power systems, there is an increased need for flexibility to accommodate vagaries and deviations from forecasts. System operators allocate flexibility via headroom and ramping requirements in the form of reserves. Reserves are typically held in day-ahead cycles and released in real-time cycles. Excessive amounts of reserve result in unnecessarily expensive schedules, and insufficient reserve results in poor system reliability. A practical method to determine exact reserve needs that do not require scheduling re-formulation (e.g., stochastic or robust) is proposed, and its advantages in terms of cost and system reliability are studied.

■ TA84

S- Ravenna A

Equilibrium Models in Energy II

Sponsored: Energy, Natural Res & the Environment/Energy Sponsored Session

Chair: Steven A Gabriel, University of Maryland, College Park, MD, 20742-3021, United States

Co-Chair: Simon Risanger, Norwegian University of Science and Technology (NTNU), Alfred Getz vei 3, Trondheim, 7034, Norway

1 - An Equilibrium Approach Assessing Tariff Designs for Local Energy Markets in the Context of Active Consumers

Magnus Askeland, SINTEF Energy Research, Trondheim, Norway, Magnus.Askeland@sintef.no, Norwegian University of Science and Technology, Trondheim, Norway, Thorsten Burandt, Steven A. Gabriel

As consumers go from passive to active, it is necessary to consider if the price signals from the grid are enough to promote optimal utilization of the decentralized resources in the context of the larger power system. The research considers tariff design options in the context of active consumers that can participate in both local and centralized electricity markets. The interaction between a neighborhood with the possibility of a local market and the grid is modeled as a complementarity problem. The results provide insight into the appropriateness of different tariff design structures and an assessment of the impact of a local market on the deployment and operation of decentralized resources.

2 - Redispatch in Zonal Pricing Electricity Markets

Mario Blazquez de Paz, NTNU, Trondheim, Netherlands, mario.blazquezdepaz@ntnu.no

Zonal markets operate sequentially. First, the suppliers compete in a spot market. Second, to alleviate the congestion in the transmission line, in a redisptach market, the suppliers in the importing node are called into operation to increase their production, and the suppliers in the exporting node are compensanted to reduce their production. I characterize the equilibrium in a zonal market when the competition is imperfect and the spot and redispatch markets operate sequentially. I find that the consumers' welfare and suppliers' profits depend crucially on the type of redispatch design implemented by the auctioneer, and that could introduce long term investment distortions.

3 - Equilibrium Models for Modelling an Oligopoly with a Competitive Fringe

Mel Devine, University College-Dublin, Dublin, Ireland, meldevine07@gmail.com

Mixed Complementarity Problems (MCPs) are typically used to model strategic in energy market models. However, when market power is characterised by an oligopoly with a competitive fringe, myopic and unrealistic behaviour is observed. To overcome this issue, we also present an Equilibrium Problem with Equilibrium Constraints (EPEC) model and detail how market power influences investment decisions. However, EPECs are much a more complex model and thus cannot model the same level of operational detail as an MCP. Consequently, we also discuss the modelling trade-offs between using an MCP and an EPEC when modelling electricity markets characterised by an oligopoly with a competitive fringe.

4 - From Linking to Integration of Energy System Models and Computational General Equilibrium Models

Asgeir Tomasgard, Norwegian University of Science and Technology, Dept. of industrial economics, Alfred getz vei 3, Trondheim, 7491, Norway, asgeir.tomasgard@iot.ntnu.no, Per Ivar Helgesen

This paper compares hard-linked and integrated approaches of hybrid top-down and bottom-up models in terms of equilibria and convergence. The integrated model provides the same solutions as the hard-linked models. Also, an alternative integrated model is provided, where the bottom-up model objective is optimized while the top-down model is included as additional constraints. This nonlinear program corresponds to a multi-follower bilevel formulation, with the energy system model as the leader and the general equilibrium players (firms and household) as followers.

5 - New Formulation of Unit Commitment Model with Near Integer Solution of Continuous Relaxation and Associated Algorithms

J. David Fuller, Professor Emeritus, University of Waterloo, Waterloo, ON, Canada, dfuller@uwaterloo.ca

The optimal solution of the continuous relaxation of a reformulated single-hour unit commitment (UC) model has a simple structure: ranking generators by their minimum prices to be profitable, the cheapest have on/off binary variables equal to 1; at most one has a binary variable between 0 and 1; the remainder have 0 binaries; and the market price is either the minimum price of the most expensive generator with a nonzero binary, or greater than this but less than the next most expensive. A simple algorithm finds the optimal solution quickly, and rounding (if necessary) finds a good integer solution. The multi-hour UC model has similar properties each hour, suggesting possible algorithms for it.

■ TA85

S- Ravenna B

Energy Sharing and Trading in Integrated Energy Systems

Sponsored: Energy, Natural Res & the Environment/Energy

Sponsored Session

Chair: Rui Dai, University of South Florida, Tampa, FL, 33613, United States

Co-Chair: Hadi Charkhgard, University of South Florida, Tampa, FL, 33620-5350, United States

1 - Integrated Electrical-Thermal Operation of Residential Building Equipped with Hydro-pneumatic Energy Storage

Yang Chen, Ph. D., Oak Ridge National Laboratory, Oak Ridge, TN, 37830, United States, Fadwa Dababneh, Saiid Kassaee, Ayyoub Momen, Brennan Smith

The building sector is responsible for a large portion of total global energy consumption and carbon emissions. Using a novel hydro-pneumatic energy storage (GLIDES) invented in Oak Ridge National Laboratory, opportunities for leveraging this low grade heat in residential building can be amplified. In thisresearch, the potential of utilizing thermal energy from different energy sources to augment electricity generation of GLIDES is investigated. Due to nonlinear thermal dynamics, a mixed integer nonlinear model is formulated for day-ahead domestic energy system operation planning at 5-minutes time step. Resultsshow that more cost savings and higher energy efficiency could be achieved.

2 - Multi-user Energy Storage Sharing Based on the Nash Bargaining Solution

Rui Dai, University of South Florida, Tampa, FL, 33613, United States, ruidai@mail.usf.edu, Hadi Charkhgard, Mohammad Javad Feizollahi

Efficient energy storage sharing should coordinate the conflict of efficiency and fairness. The efficiency requires the strategy to create higher energy arbitrage. The fairness ensures the stored energy is fairly exchanged among multiple users and the arbitrage is properly allocated. To address this challenge, we propose a Nash Bargaining Solution based sharing strategy for energy storage sharing to balance the conflict of efficiency and fairness. This strategy creates a compensation mechanism to realize the fair exchange of the stored energy. The computational study shows that the proposed sharing strategy outperforms the reference strategies in terms of efficiency and fairness.

3 - A Robust bi-objective Optimization Approach for Energy Storage Sharing under-price Uncertainty

Hadi Charkhgard, University of South Florida, Tampa, FL, 33620-5350, United States, Rui Dai

Energy storage sharing can boost energy arbitrage by allowing the users to exchange their stored energy in contrast to using the energy storage independently. However, it is hard to assure this arbitrage under prices uncertainty. We present a robust bi-objective optimization approach to fairly and efficiently operate an energy storage shared by two users under price uncertainty. To facilitate solution efficiency, we propose a tractable binary formulation for piecewise McCormick relaxations. The computational study demonstrates the effectiveness of our robust sharing strategy and the efficiency of the binary formulation for piecewise McCormick relaxations.

4 - A Bilevel Conic Optimization Model for Routing and Charging of Electric Vehicles.

Vignesh Subramanian, University of South Florida, Tampa, FL, 33617, United States, vigneshs@mail.usf.edu, Kevin A. Melendez, Felipe A. Feijoo, Sriram Sankaranarayanan, Tapas K. Das

A bilevel electric-transportation model that uses a conic AC power flow formulation is presented in this paper. The upper level determines both the optimal route for the electric vehicles (EVs) by minimizing the cost (given the location marginal price, LMP) of charging, and the EV charging facility locations. The lower level represents electric system operator and solves for market clearing decision to determine the LMPs for the charging stations (a large increase of EVs demand will affect LMPs). Since, charging of EVs require reactive power support from the electricity grid. To model for this, an AC power flow formulation is used to account for the reactive power balance in the network.

■ TA86

S- Ravenna C

Smart Manufacturing

Emerging Topic: Advanced Manufacturing

Emerging Topic Session

Chair: Hui Yang, Pennsylvania State University, University Park, PA

1 - Online Optimal Parameter Settings for Additive Manufacturing Processes by Reinforcement Learning with Knowledge Transfer

Zhenyu Kong, Virginia Tech, Dept of Industrial and Systems Engineering, Blacksburg, VA, 24061, United States, zkong@vt.edu, Jihoon Chung

Since additive manufacturing (AM) can produce complex 3-D geometries with various types of materials, the machine parameter settings may need to be adjusted adaptively. Traditionally design of experiment (DOE) has been utilized to identify the optimal machine parameter setting. However, DOE method cannot handle the complexity of AM processes. To overcome this challenge, we proposed a method that integrates offline (DOE) and online reinforcement learning, and can also accelerate learning rate by knowledge transfer during the printing process.

2 - Data Driven Modeling of Thermal History for Additive Manufacturing

Linkan Bian, Mississippi State University, Industrial and Systems Engineering Department, PO Box 9542, Mississippi State University, MS, 39762, United States, bian@ise.msstate.edu

Our objective in this study is to develop an efficient thermal history prediction of AM processes in a layer-track manner using thermal image streams. Most of the existing physics-based models are not able to provide comprehensive understanding of AM processes. We propose a network-tensor structure for freeform shapes based on thermal image streams obtained in metal-based AM process. The proposed approach is validated using numerical models and experimental data.

3 - The Internet of Things for Smart Manufacturing

Hui Yang, Pennsylvania State University, Industrial and Manufacturing Engineering, University Park, PA, 16801, United States, Soundar Kumara, Satish T. Bukkapatnam, Fugee Tsung

Modern manufacturing industry is investing in new technologies such as the Internet of Things (IoT), big data analytics, cloud computing and cybersecurity to cope with system complexity, increase information visibility, improve production performance, and gain competitive advantages in the global market. These advances are rapidly enabling a new generation of smart manufacturing, i.e., a cyber-physical system tightly integrating manufacturing enterprises in the physical world with virtual enterprises in cyberspace. To a great extent, realizing the full potential of cyber-physical systems depends on the development of new methodologies on the Internet of Manufacturing Things (IoMT) for data-enabled engineering innovations. This talk presents a review of the IoT technologies and systems that are the drivers and foundations of data-driven innovations in smart manufacturing.

■ TA88

S- Cedar A

Health Care, Modeling and Optimization IX

Contributed Session

Chair: Ashkan Hassani, Texas A&M University, College Station, TX, 77840, United States

1 - Operational Impact of mHealth Adoption in Clinical Practice

Balaraman Rajan, Assistant Professor, California State University East Bay, Hayward, CA, United States, Saligrama Agnihothri, Arvind Sainathan

Chronic conditions place a high cost burden on a healthcare system and deplete the quality of life for millions of patients. There is significant medical literature showing that continuous monitoring of patient health at home with the addition of provider support, improves patient health. Digital innovations such as mHealth technology can help provide efficient, effective, and patient centered healthcare. However, implementing mHealth technology can also significantly change the composition of clinical staff and patient flow. We use patient health progression models and queuing analyses to evaluate the trade-offs from implementing mHealth technology in a clinical practice.

2 - Predictive Decision Analytics for Interpretable Elderly Readmission Healthcaring

Jiandong Zhou, City University of Hong Kong, Kowloon, Hong Kong, jiandzhou3-c@my.cityu.edu.hk, Qingpeng Zhang, Frank Y. Chen, Eman Leung

Predictive decision analytics act as core module of healthcare systems for preventable readmissions mitigation to deliver high-quality healthcare services with lower cost and higher efficiency. We develop an easy-for-use and provable predictive analytics model, termed as field-aware interpretable factorization machine (FIFM), to predict elderly patient readmissions with full interpretability via histograms and heatmaps. We test our model using a unique large-scale clinical dataset in Hong Kong, showing its superiority over extant regression and black-box-like machine learning models. Resource allocation decisions are optimized with the results of readmission predictive analytics.

3 - Dynamic Tuberculosis Test Scheduling for Healthcare Employees

Mahsa Kiani, Clemson University, Clemson, SC, United States, Burak Eksioglu, Tugce Isik

Tuberculosis (TB) is a contagious disease. There are two TB tests on the market: skin test and blood test. The cost of the blood test is much higher than the skin test. But, the possibility of getting a false positive result in skin test is higher especially for persons with specific characteristics. This causes an extra cost of X-Ray test. TB screening is required annually for healthcare employees. In our study, we create a Markov decision process model to decide which TB test should be done by each group of employee based on the characteristics of the group to decrease the total cost and infection rate. Due to the curse of dimensionality, we use approximate dynamic programming to approximate the solution.

4 - Surgery and Resource Scheduling in Operating Theater

Thierry Garaix, Mines Saint-Etienne, Saint-Etienne, France, garaix@emse.fr, Roberto Bargetto, Xiaolan Xie

The scientific contribution of this work is a Column Generation algorithm and the overlying Branch-and-Price-and-Cut algorithm to solve the Integrated Operating Theater Planning Problem. In addition to previous researches, the surgeon can operate in different operating rooms the same day, nurse capacity is accurately taken into account by specialty and their over working time IS minimized. The proposed approach is applied to instances from the hospital CHU Saint-Etienne, and to published benchmarks for a comparison against state-of-the-art algorithms.

5 - A Multi-attribute Optimization Approach for Post-acute Provider Selection

Ashkan Hassani, Texas A&M University, College Station, TX, United States, ashkanhassani@tamu.edu, Hossein Badri, Maryam Khatami, Kai Yang, Mark Alan Lawley

In this study a decision making approach is developed for Post-Acute Care Provider (PACP) selection problem. This approach includes two stages. In the first stage, some quality metrics are used in a TOPSIS method to calculate the closeness coefficients of each candidate PACP to shortstay patient's and long-stay patients. In the second stage, these coefficients are used in a mathematical programming model, along with some other cost and service level metrics to select the best PACP's for both short-stay and long-stay patients. The proposed approach is implemented for PACP selection problem in the city of Houston, TX, and the results are presented and analyzed.

■ TA89

S- Cedar B

Systemic Risk and Financial Contagion

Sponsored: Finance

Sponsored Session

Chair: Zach Feinstein

1 - Pricing in an Eisenberg-Noe Framework under Comonotonic Endowments

Zachary Feinstein, Stevens Institute of Technology, Hoboken, NJ, 63130, United States, Tathagata Banerjee

In this talk we present formulas for the valuation of debt and equity of firms in a financial network under comonotonic endowments. We demonstrate that the comonotonic setting provides a lower bound to the price of debt under Eisenberg-Noe financial networks with consistent marginal endowments. Such financial networks encode the interconnection of firms through debt claims. The proposed pricing formulas consider the realized, endogenous, recovery rate on debt claims. Special consideration will be given to the setting in which firms only invest in a risk-free bond and a common risky asset following a geometric Brownian motion.

2 - Price Mediated Contagion Through Capital Ratio Requirements

Tathagata Banerjee, Washington University in St. Louis, St Louis, MO, 63108, United States, tbanerjee@wustl.edu, Zachary Feinstein

We develop a framework for price-mediated contagion in financial systems where banks are forced to liquidate assets to satisfy a risk-weight based capital ratio requirement after an exogenous shock to the system. We consider the case of multiple illiquid assets and develop conditions for existence and uniqueness of equilibrium prices. We show that sensitivity analysis of these prices with respect to the system parameters can be written as a fixed point problem and we prove the existence and uniqueness of this fixed point problem. We also develop a methodology to quantify and compare the risk posed by the different banks. Numerical case studies are provided to study the application of this model to data.

3 - Value and Size Effects

Andrey Sarantsev, University of Nevada, Reno, Davidson Math & Science Center 314, Mathematics & Statistics, Reno, NV, 89557, United States, asarantsev@unr.edu

We compare exchange-traded funds issued by leading financial companies, such as Vanguard, to verify the famous statement by Fama and French (1993) that value stocks outperform growth stocks, and small-cap stocks outperform large-cap stocks.

4 - An Adaptive Learning Agent Approach to Interbank Market Liquidity Hoarding Risk

Steve Yang, Stevens Institute of Technology, Babbio Center #536, Castle Point on Hudson, Hoboken, NJ, 07030, United States, steve.yang@stevens.edu, Xingjia Zhang

This paper investigates how the counterparty risk can lead to dry-up of liquidity in the interbank market with learning agents. Using policy gradient reinforcement learning agents, we demonstrate the adaptive learning banks can endogenously form liquidity hoarding phenomenon under an exogenous shock to the system. We incorporate RE sales and study how RE sales would affect interbank lending market dynamics, and the results show that RE sales exert negative effect on liquidity hoarding, and they tend to drive banks to increase the interbank lending in order to balance their market risk under a distressed market.

■ TA90

S- Redwood A

Designing Service System for Electric Vehicles

Sponsored: Location Analysis

Sponsored Session

Chair: Ismail Capar, Texas A&M University, College Station, TX, 77843-3367, United States

Co-Chair: Ibrahim Capar, Bowling Green State University, Bowling Green, OH, 43403, United States

Co-Chair: Yudai Honma, The University of Tokyo, Tokyo, 153-8505, Japan

1 - Relationships between AFV Demand Assumptions and AFS Optimal Locations: A Case Study of Tokyo

Yudai Honma, The University of Tokyo, Ce405, Tokyo, 153-8505, Japan, yudai@iis.u-tokyo.ac.jp

In this study, based on the real GIS data in the Tokyo region, relationships between AFV demand assumptions and AFS optimal locations are discussed in detail. For the comparison, two station location models are introduced that extend the Flow Capturing Location Model (FCLM) and p-Median Problem (PMP) by consistently defining upper limits on vehicle driving range and maximum inconvenience on refueling trips. Both models are also extended to the multi-objective models between the node-based and path-based objectives.

2 - Analysis of Streetscape Impression Based on Deep Learning for Autonomous Vehicles

Tomoaki Fukuzumi, The University of Tokyo, Tokyo, 1538505, Japan, fukuzumi@iis.u-tokyo.ac.jp, Yudai Honma

In this study, we quantify the "impression" of streetscapes using the image processing methods. Since image processing methods have been researched actively in the field of computer vision, we can extend the study by using such latest progress. We are now considering to detect each segment based on deep learning library for the autonomous vehicle. It will enable us to collect visual information as more mathematics-friendly data.

3 - The Impact of Load on the Energy Consumption and Route Planning of Electric Freight Vehicles

Bülent Çatay, Sabanci University, Faculty of Engineering and Natural Sciences, Tuzla, Istanbul, 34956, Turkey, catay@sabanciuniv.edu, Sina Rastani, Tugce Yuksel

Despite the advancements in battery technology, range anxiety still constitutes a major barrier to the adoption of EVs in freight transport operations. Since cargo weight can significantly affect the energy consumption, it should be taken into account for effective route planning. In this study, we revisit the Electric VRP with Time Windows by considering load factor. We present a mixed integer linear programming formulation of the problem and perform an extensive experimental study using benchmark data from the literature to investigate how cargo weight influences energy consumption and routing decisions. Our aim is to present managerial insights to both researchers and practitioners.

4 - Assessment of EV Charging Network Design under Various Service Metrics

Ibrahim Capar, Bowling Green State University, Department of ASOR, 355 Business Administration Building, Bowling Green, OH, 43403, United States, icapar@bgsu.edu, Ismail Capar, Ozgur M. Araz

In this research, we present a service network design framework to improve the electric vehicle infrastructure with quality of service constraints taken into consideration. Specifically, we consider a flow-refueling location model with capacitated charging stations and budget constraints. We capture the average waiting time on the network in addition to the total flow captured. We propose several new objective functions to capture the tradeoff between the total waiting time and the total flow captured.

5 - A Novel Location-allocation-routing Model for Siting Multiple Recharging Points on the Continuous Network Space

Pitu B. Mirchandani, Arizona State University, School of Computing, Informatics and, Decision System, Tempe, AZ, 85287, United States, Yazhu Song

While automobile companies and governments are trying to incentivize greater use of electric vehicles, they are still not widely used due to a sparse charging infrastructure. This talk introduces a new location-allocation model for siting battery recharging points (RPs) on the continuous points on a network to minimize total detouring of trips from origins (O) to destinations (D). Since the cost of a RP is generally high, the talk first addresses the problem of finding the minimum number of RPs to "cover" all the OD trips. The talk then addresses the problem of locating these RPs as well as how to route EVs to result in the least total detouring. Problem complexity and solution algorithms are presented.

■ TA91

S- Redwood B

Emerging Topics in Coordinated Care and Organization Performance

Sponsored: Manufacturing & Service Oper. Mgmt/Healthcare Operations

Sponsored Session

Chair: Pengyi Shi, Purdue University, West Lafayette, IN, 47907, United States

Co-Chair: Nan Liu, Boston College, Chestnut Hill, MA, 02467, United States

1 - Coordinated Care for Mental and Physical Health

Sandeep Rath, Assistant Professor, University of North Carolina at Chapel Hill - Kenan Flagler, CB #3490, McColl Building, McColl 4705, Chapel Hill, NC, 27599, United States, sandeep@unc.edu, Jayashankar M. Swaminathan

Multiple clinical trials have demonstrated the benefits of coordinating treatment of mental health conditions like depression and chronic physical conditions like diabetes. However, sustainability of coordinated care outside trial settings has not been fully demonstrated. A sustainable coordinated care will be revenue neutral for the providers and improve patient outcomes. Towards this, we propose a mathematical optimization model which would optimize care management plans to improve patient outcome while balancing revenue and resource usage costs.

2 - Length-of-stay Prediction and its Application to Optimal Staffing for Long-term Rehabilitation Facilities

Eugene Furman, PhD Candidate, Schulich School of Business, Toronto, ON, M3J 1P3, Canada, enfurman@mathstat.yorku.ca, Adam Diamant, Andre Augusto Cire

Using extensive data from a rehabilitation company in the U.S., we use a Bayesian inference framework to predict treatment duration for patients who require long-term care due to brain and spinal-cord injuries. Specifically, we implement a mixture hidden Markov model and show that patients can be clustered into different latent categories. Then, using referral data to predict cluster membership, we leverage this prediction tool to forecast the workload of medical practitioners and support personnel in order to design practical and effective staffing policies.

3 - Rich Dad Poor Dad: A Perspective of Operational Fit on the Acquisition Performance of Multiunit Service Organizations

Kejia Hu, Vanderbilt University, Nashville, TN, 37215, United States, Lauren Xiaoyuan Lu, Susan F. Lu

We study how merge and acquisition affect nursing homes performance and the chains acquired it.

4 - Empirical Analysis of the Impact of Operational Factors on Clinical Decision Making in a Chronic Care Clinic

Zehra Onen, Koc University, Istanbul, Turkey, zeonen@ku.edu.tr, Evrim D. Gunes, Tolga Tezcan, Raj Sengupta

The rising prevalence of chronic conditions (for which there is currently no cure, and which are managed with drugs and other treatment) is one of the main challenges facing health-care systems globally. We investigate how non-clinical operational factors affect clinical decisions of health professionals using 75,702 patient visit data from a rheumatology outpatient clinic in Bath, UK. We focus particularly on the decision to follow-up or discharge a patient and re-attendance of discharged patients. We show that increasing workload and patient waitlist size decrease discharges and increase re-attendances. By contrast, continuity of care increases discharges and decreases re-attendances.

■ TA93

S- Grand Ballroom B

Information Systems II

Contributed Session

Chair: Xiaoxi Liu, Korea University, Seoul, 02841, Korea, Republic of

1 - Agglomeration or Competition: How Online Reviews Change the Effect of Firm Geographical Clustering on Revenue

Kezhen Wei, Xi'an Jiaotong University, Xi'an, China, kezhenw001@126.com, Shan Liu, Baojun Gao

This paper develops a model of how online consumer reviews change the influence of firm geographical clustering on its revenue. Based on 32,087 observations of 1,170 Texas hotels consisting of tax data and online reviews, we analyze the dynamic panel data using a Generalized Method of Moments approach. Our results reveal that firm geographical clustering positively affects revenue, indicating an agglomeration rather than a competition effect. However, such effect decreases with the increase of consumer online reviews, regardless of whether the reviews are positive or negative. Our findings provide important implications on the offline competition with online channels.

2 - The Effects of Prior Experiences on Current Weight Loss Outcome in Online Weight Loss Communities

Lun Li, Beijing Institute of Technology, Beijing, China, 2120171541@bit.edu.cn, Zhijun Yan, Qiuju Yin, Junwei Kuang, Chenxi Guo

This study explores the effects of prior weight loss experiences on the current weight loss outcome using a dataset from an online weight loss community. We find that successful prior experiences have a positive effect on the result of current weight loss session while failure experiences create negative effects. Moreover, online social support enhances the positive impact of successful experiences and decrease the negative effects of failure experiences. In addition, there are significant gender differences.

3 - Designing Social Products: An Analysis of the Effects of Social Influence

Xiaoxi Liu, Korea University, Seoul, Korea, Republic of, polar1018@korea.ac.kr, Byung Cho Kim

It is well acknowledged that consumers looking to signal their uniqueness by consuming scarcity goods. The consumer psychology of pursuing uniqueness is also manifested in social products, in a way that users who have the desire for uniqueness will choose the social products which distinguish themselves from others in terms of interests, hobbies or purposes. In this paper, we propose an analytical model of conspicuous consumption on social products using the rational expectation framework and examine how social effects and market structure can influence the design of social products. We examine both the monopoly and duopoly cases to investigate the optimal design of social products.

4 - The Mediating Role of Empathy in Effort Allocation in Question & Answer Online Communities

Tao Wang, Simon Fraser University, Vancouver, ON, Canada, wangtaow@sfu.ca

The answers created in Question & Answer online communities can range from very brief to very detailed. How do people determine the amount of cognitive efforts when replying questions? Adopting the 'empathy-altruism hypothesis,' I suggest that the displayed emotions can lead to affective empathy and affect the level of cognitive effort. The similarity of the question and the replier's expertise can have positive impact on the cognitive empathy, which will affect the level of cognitive effort as well. I draw support from the empirical study using the log data of an entrepreneurship forum of Reddit.com from 2012 to 2018.

5 - Crying Baby Gets the Milk? Displayed Emotions and Knowledge Acquisition in Online Communities of Entrepreneurs

Tao Wang, Simon Fraser University, Vancouver, BC, Canada, wangtaow@sfu.ca

How does displayed emotions in Question & Answer online communities affect the knowledge acquisition? Using the log data of an entrepreneurship forum of Reddit.com from 2012 to 2018, I examine the dynamics of dyad formation and the usefulness of knowledge under the variation of displayed emotions in question. I argue that the negative emotions (sadness and anxiety) displayed in the questions affect the occurrence of knowledge acquisition as well as have positive impact on the usefulness of the knowledge acquired. In addition, knowledge specificity drives different paths for the negative emotions affecting the usefulness of knowledge.

6 - Mechanism Design for Online Marketplace Lending with Institutional Investors

Anparasan Mahalingam, Purdue University, Krannert Building, West Lafayette, IN, 47906, United States, Mohammed Alyakoob, Mohammad Saifur Rahman

A relatively new strand of management scholarship studies the strategic concerns of mechanism design in online platform markets. In this paper, we examine the ex-post performance implications arising from ex-ante mechanism design choices for a peer-to-peer lending platform with heterogeneous participants. We demonstrate how seemingly innocuous platform mechanism design choices related to lender side expansion, through incorporating institutional lenders, can have negative spillover effects on the market and far reaching implications for all market players—focal platform, lenders and borrowers.

■ TA94

S- Grand Ballroom C

Modeling and Optimization of Biomanufacturing Operations

Sponsored: Manufacturing & Service Oper. Mgmt/Healthcare Operations

Sponsored Session

Chair: Tugce Martagan, Eindhoven University of Technology, Eindhoven, 5611AZ, Netherlands

1 - Achieving Coordination via Effort-based Contracts for Biopharmaceutical Projects

Yasemin Limon, University of Wisconsin-Madison, Madison, WI, 53705, United States, ylimon@wisc.edu, Tugce Martagan, Ananth Krishnamurthy

In biopharmaceutical drug development, achieving the desired yield and quality involves high uncertainty and costs. Large biopharmaceutical companies and niche biotech companies often collaborate to leverage individual capabilities, reduce risks and lower costs. We investigate the performance of various contract designs for this supply chain. We show that fixed-price and revenue sharing contracts may not coordinate, but effort-based contracts can achieve supply chain coordination.

2 - Optimal Subsidies for Early Access to Rare Disease Therapeutics

Tugce Martagan, Eindhoven University of Technology, Eindhoven, Netherlands, t.g.martagan@tue.nl, Wendy Olsder, Christopher S. Tang

We consider subsidies to encourage faster access to rare disease treatments. We present a three-stage Stackelberg game to determine an optimal allocation of a limited subsidy budget (i.e., subsidize patients only, manufacturers only or both). We consider different pricing schemes, and characterize the optimal R&D effort and the unit selling price for rare disease treatments.

3 - A Systematic Risk Analysis and Sensitivity Analysis Framework to Facilitate Biopharmaceutical Production Learning and Stability Improvement

Wei Xie, Northeastern University, Boston, MA, 02115, United States, w.xie@northeastern.edu, Bo Wang, Cheng Li, Jared Auclair

Since there are many process parameters and quality attributes impacting on the bio-drug product quality, we propose a risk and sensitivity analysis framework to quantify their criticality and further identify dominate factors to monitor and control. We first develop Bayesian Network-based risk analysis for integrated production process to assess the criticality of process parameters and quality attributes. Then, we propose uncertainty quantification and sensitivity analysis to facilitate the science-based monitoring and learning for the production process stability control.

4 - Optimal Harvesting and Replenishment Decisions to Reduce Changeovers in Biomanufacturing

Yesim Koca, Eindhoven University of Technology, Eindhoven, 5600MB, Netherlands, Tugce Martagan, Lisa M. Maillart, Ivo Adan

We develop an MDP model to reduce the number of changeovers in biomanufacturing fermentation processes. We determine optimal harvesting and replenishment policies that maximize the expected total discounted profit in the long run. We analyze structural characteristics of the optimal policies and illustrate the industry use of the model through a case study.

■ TA95

S- Grand Ballroom D

Joint Session MIF/HAS: Cancer Care and Health Disparities

Sponsored: Minority Issues

Sponsored Session

Chair: Karen T. Hicklin, University of North Carolina at Chapel Hill, Chapel Hill, NC, 27599-7411, United States

1 - Incorporating Patient Preferences and Risk of Overdiagnosis in Breast Cancer Treatment Decisions

Juan David Bolivar, Universidad de los Andes, Bogotá, Colombia, Shengfan Zhang, Raha Akhavan-Tabatabaei, Ahla Ko

The importance of shared decision making in cancer care has been increasingly recognized in the medical community. Cancer patients are working more closely with care providers to choose the best treatment plan. In particular for breast cancer, a number of treatment alternatives are available, each with different side effects that could significantly impact patients both physically and psychologically. We develop a dynamic decision model to determine the optimal breast cancer treatment selection that incorporates not only medical considerations but also a quantitative measure of personal preferences.

2 - Optimization of Telemedicine Clinic Locations for Increasing Access to Bladder Cancer Screening

Ayca Erdogan, Assistant Professor, San Jose State University, Davidson College of Engineering, Industrial and Systems Engineering, San Jose, CA, 95192, United States, ayca.erdogan@sjsu.edu, Van Khanh Phan, Tracey Krupski, Jennifer Mason-Lobo

Telemedicine aims to increase patients' access from rural or remote areas to specialty care that is not locally available. We present a model to determine the locations of telemedicine clinics to open with the aim of maximizing patient access/adherence. The model is developed and tested for the purpose of opening telemedicine clinics to reduce disparities in rural Virginia by increasing bladder cancer screening, diagnosis and treatment. We assume that patients can choose either the central hospital or a telemedicine clinic and their adherence is affected by the distance they need to travel.

3 - The Making of Practice Guidelines-Dynamics of Selection and Detection Criteria in Population Screening

Ozge Karanfil, Harvard University School of Public Health, Cambridge, MA, 02140, United States, okaranfil@ku.edu.tr

Clinical practice guidelines (CPGs) for routine screening are contentious and often fluctuate over time. We develop the first broad boundary feedback theory and formal model to explain dynamics of screening policy formation. Our behaviourally realistic model of detection and selection for screening explains oscillations in CPGs as decision makers weigh harms and benefits. The model endogenously generates fluctuations in policy thresholds leading suboptimal guidelines. We use cancer screening as a motivating example, but the model is generic and applicable to other diseases such as Alzheimers or to nonmedical contexts such as airport screening, background checks or automotive emission tests

4 - Assessing the Impact of Multicomponent Interventions on Colorectal Cancer Screening: What Would it Take to Reach the 80% Target?

Karen T. Hicklin, University of North Carolina at Chapel Hill, Campus Box 7411, Chapel Hill, NC, 27599-7411, United States, khicklin@email.unc.edu, Meghan C. O'Leary, Siddhartha Nambiar, Maria E. Mayorga, Kristen Hassmiller, Melinda M. Davis, Stephanie B. Wheeler

Healthy People 2020 and the National Colorectal Cancer Roundtable have set national colorectal cancer (CRC) screening targets at 70.5% and 80%, respectively. While CRC screening has increased in recent years, with approximately two-thirds of age-eligible individuals screened, the feasibility of these targets at the population level remains uncertain. We use microsimulation to identify which combinations of multicomponent interventions and health policy changes may be capable of achieving current targets in North Carolina in addition to the long-term effects on CRC incidence and mortality.

5 - Pancreatic Cancer Screening Impact: Effort to Screen and Five-year Survival Rates

Julie Simmons Ivy, North Carolina State University, Raleigh, NC, Lena Abu-El-Haija

Pancreatic cancer is a deadly disease with a five-year survival of 8.5%. Resection, surgical removal of the tumor, is the only cure. There have been calls for screening to detect the disease at a resectable stage to improve the chances of survival. A discrete-event simulation model for pancreatic cancer screening was developed with a resectability prediction tool upon detection. A wide range of screening policies were tested on heterogeneous and homogeneous populations. The resulting tradeoff between five-year survival and the effort to screen under each policy was assessed. Effort versus five-year survival efficiency frontiers were used to identify policies by race, gender, and relative risk.

■ TA96

S- Willow A

Data Mining II

Contributed Session

Chair: Ghazal Shams, Arizona State University, Tempe, AZ, 85282, United States

1 - Flexboost: A Flexible Boosting Algorithm with Adaptive Loss Functions

Dong-Hyuk Yang, Sungkyunkwan University, Gyeonggi-do, Korea, Republic of, wayne0831@skku.edu, Yong-Seok Jeon, Dong-Joon Lim

AdaBoost is an algorithm that can build a strong classifier by optimally combining weak classifiers in such a way that subsequent weak classifiers are tweaked in favor of instances misclassified by previous classifiers. However, It is known to be susceptible to overfitting problems due to the static nature of its weight-updating process. In this paper, we propose a new boosting algorithm, named FlexBoost (Flexible AdaBoost), that can enhance classification performance by employing adaptive loss functions for each weak classifier. The performance benchmarks on 30 binary classification problems taken from the UCI and Kaggle datasets are presented to empirically validate the proposed algorithm.

2 - Application of Multivariate Analysis in Prediction of Absenteeism at Work

Motahareh Tavakolikashi, Student, Binghamton University, Binghamton, NY, United States, Naseem Khan, Yuqiao Cen, Shuxia Susan Lu

In the highly competitive market, the urge to produce more with utilizing fewer resources puts lots of pressure on employees and causes absenteeism at work. In this paper, first different feature selection methods are implemented to identify the most important attributes. Then, different machine learning algorithms (Decision Tree, Naïve Bayes, Logistic Regression and Linear Discriminant Analysis) have been implemented to achieve an accurate predictive model for absenteeism. The performance of these algorithms is evaluated by several metrics including accuracy, sensitivity, specificity, and AUC of the ROC curve. The results show that the DT algorithm outperforms other algorithms.

3 - Image Decomposition-based Sparse Extreme Pixel-level Feature Detection with Application to Medical Treatment Planning

Jialei Chen, Georgia Institute of Technology, Atlanta, GA, United States, Geet Lahoti, Zhen Qian, Chuck Zhang

While planning medical treatment, it is important to identify, (a) calcification as positive extreme features and (b) soft tissues as negative extreme features, from a computed tomography image of the human heart. We propose a novel, automatic image decomposition-based sparse extreme pixel-level feature detection model to decompose an image into mean and extreme features. To estimate model parameters, a high-dimensional least squares regression is utilized. An algorithm based on the alternating direction method of multipliers and the proximal gradient method is developed to solve the optimization problem.

4 - Hierarchical Structured Sparse Learning in Biomedical Data Analytics

Fangyun Bai, Tongji University, Shanghai, China, baifyr@163.com, Shouyi Wang, Wenyong Zhou

Investigation of massive biomedical data to advance knowledge and medical breakthroughs has taken a center stage in modern data analysis. Although complex, the underlying representations of most biomedical data are often sparse. In this talk, we will present a hierarchical structured sparse learning method as a powerful tool to model high-dimensional biomedical data, and provide with high degree of model interpretability for knowledge discovery.

5 - A Dual Model Agnostic Strategy to Explore Representativeness and Informativeness in Active Learning

Ghazal Shams, Arizona State University, Tempe, AZ, United States, gshams@asu.edu, Enrique Del Castillo, George Runger

Active learning techniques have shown promising results in accelerating learning procedures while reducing the cost of data annotation. Although density based strategies have been widely adopted to improve uncertainty based techniques in active learning, they do not take the uncertainty associated with our understanding of perplex high-dimensional feature space into account. In this work, we propose a stochastic label query strategy for pool-based active learning based on a coherent and consistent measure that unifies classification and input data structure uncertainties.

■ TA97

S- Willow B

Supply Chain Management, Green

Contributed Session

Chair: Olga Battaïa, ISAE-SUPAERO, Toulouse, 31055, France

1 - Sustainability as a Vehicle for Value Innovation: Recent Case Studies

Suri Gurumurthi, Hong Kong University of Science and Technology, Culver City, CA, United States

In recent successful cases of value innovation driven by sustainability initiatives, a gradual, continuous, and optimized investment in waste reduction and efficiency gains across the supply chain results in a competitive cost structure for the firm. Leveraging this stable platform, breakthrough investment in sustainable processes and technologies then creates a powerful differentiator for the firm in its industry. Together, we propose that a hybrid strategy of continuous improvement across the supply chain, coupled with breakthrough investment in sustainability can potentially deliver value innovation in the industry at relatively lower risk of failure.

2 - Analytical Approaches to Study the Impact of Environmental Regulations and Customer Environmental Awareness on the Sourcing Strategy

Olga Battaïa, ISAE-SUPAERO, Toulouse, France, olga.battaia@isae-supaero.fr, Narjes Kandil, Ramzi Hammami

We consider an outsourcing problem under economic, environmental and social considerations for a profit-maximizing firm having the possibility of producing in-house or outsourcing a part of its production process to a foreign country. The firm faces a carbon tax and demand and cost uncertainties. We develop analytical approaches to study the impact of environmental regulations and customer environmental awareness on the sourcing strategy and the green investment of the firm.

3 - The Competition and Cooperation for Green Product Producing in Supply Chains

Xifei Liu, Peking University, Beijing, China, Shuxiao Sun

The sustainable supply chain has attracted a lot of attention not only in the industry but also in the academic society. This study focuses on the pricing and determination of the degree of greenness (eco-friendliness) of two substitute products. The two kinds of products are produced by two competing manufacturers while they can cooperate with each other to improve the degree of greenness.

Tuesday, 9:30AM - 10:20AM

■ Plenary

CC- Room 6E

Plenary: Planning Transportation Capacity at Amazon

Plenary Session

1 - Planning Transportation Capacity at Amazon

Russell Allgor, Amazon

Amazon has continued to speed up delivery while the number of shipped packages continues to grow, shortening the time it takes between when an item is ordered and the moment that item arrives on a customer's doorstep. Prime customers experience faster delivery speeds, whether that comes from the broad selection for free two-day and one-day delivery from coast to coast, free same day delivery in select locations, or free two-hour delivery with Prime Now on tens of thousands of items. At the same time, Amazon's fulfillment business - along with that of other online retailers - has increased the pressure on parcel delivery transportation capacity both in the US and overseas. Continuing to satisfy customers' needs and increase delivery speed will require more efficient use of existing networks and the creation of additional capacity for package sortation, line haul trucking, air freight, and last mile delivery. The challenge of designing a network that can meet these dynamic needs requires us to develop technical solutions implemented through design tools that incorporate the latest process innovations. We must overcome both technical and organizational challenges to design and operate the logistics network, involving facility locations, inventory placement, facility operations, network connections, and scheduling. While the technical challenges are at least partially met through solving large-scale combinatorial optimization problems, the organizational challenges require innovative mechanisms that motivate network-wide cooperation while also allowing decentralized, scalable operation.

The presentation will cover the challenges that we face, the way we have formulated some of the problems, and some the challenges and opportunities that remain.

Tuesday, 10:30AM - 12:00PM

■ TB01

CC- Room 201

Novice Applications in Data Mining

Sponsored: Data Mining

Sponsored Session

Chair: Sara Masoud

1 - Online Assessment of Surgical Proficiency Using VR-based Hybrid Reality Simulation under Time and Situational Uncertainty

Saurabh Jain, The University of Arizona, Tucson, AZ, 85719, United States, saurabhjain@email.arizona.edu, Seunghan Lee, Barber Samuel, Eugene Chang, Young-Jun Son

Data mining has been a prominent method for evaluations of the user's proficiency within the surgical training simulation. Online feedback and appropriate assessment of the surgical skills are essential to study the underlying surgical decision-making processes under different situations based on time-crunch, risk and sleeplessness. Thus, we propose a generalized evaluation framework using the real-time data (e.g., time and motions) to provide feedback and their aggregated scores for steepening their learning curve. It will immensely reduce the cost and enhance the fidelity of surgical training.

2 - A Dynamic HMM-based Tracking Framework Utilizing UHF Passive RFID

Bijoy Dripta Barua Chowdhury, Graduate Research Assistant, University of Arizona, Tucson, AZ, 85716, United States, Sara Masoud, Young-Jun Son, Chieri Kubota, Russell Tronstad

An indoor tracking system is designed using ultra-high frequency (UHF) passive Radio Frequency Identification technology, where a K nearest-neighborhood Hidden Markov Model (HMM) is developed to track motions of moving objects by combining static localization with dynamic tracking. Statistically validated regression models are developed based on the tags' Received Signal Strength Indicator (RSSI) to estimate locations of the targeted static tagged objects, which are then augmented given the probabilistic likelihood of tags potential locations to construct the HMM. Finally, the performance of the proposed framework is evaluated by a set of experiments given different metrics.

3 - Finding a Scapegoat of the Exchange Rate Anomaly with Machine Learning Methods

Levent Bulut, Lecturer, Valdosta State University, Valdosta, GA, United States, Zeliha Gormez

When currencies are driven by unobservables shocks and fundamentals fail to explain the disconnect, the scapegoat theory of exchange rates justifies this with market participants' changing expectations about the structural parameters as they might put excessive weights to a specific fundamental, as a scapegoat, that was off-the-track at the time. In this paper, we use machine learning techniques to pinpoint the fundamentals that can serve as scapegoat factors. Our approach detected the majority of the scapegoat factors of exchange rates that were reported in the literature. We showed that while interest rates and trade gaps act as scapegoat factors, inflation rate and growth rate gaps did not.

4 - A Real-time Framework for Hand Gesture Detection

Sara Masoud, University of Arizona, Tucson, AZ, 85716, United States

Although gesture detection has been playing an important role in human-computer advanced interaction systems in a variety of applications such as gaming and virtual reality, the never-ending improvement of technology has provided new opportunities for gesture detection with more affordable, faster and more accurate sensory readings. Training and performance evaluation are emerging applications for gesture detection in many practices. Here, a semi-supervised real-time hand gesture detection framework is developed for performance evaluation based on readings provided by VMG-30 data gloves. The proposed framework is evaluated by matrices such as accuracy, precision, and f-1 score.

■ TB02

CC- Room 202

Machine Reading and Comprehension for Science-Practice Knowledge Synthesis

Sponsored: Data Mining

Sponsored Session

Chair: Victor Zitian Chen, PhD, UNC Charlotte; GoPeaks.org, Charlotte, NC, United States

1 - Detecting Causal Explanations in Natural Discourse Using Recurrent Neural Networks

Youngseo Son, Stony Brook University, Stony Brook, NY, United States, yson@cs.stonybrook.edu

Causal explanations — reasons given for happenings in one's life — are important psychologically, linked to physical and mental health, and generally give insight into one's understanding of mechanisms in the world. Automatic identification of causal explanations in social media, while challenging in many aspects, offers a larger-scale alternative to expensive manual ratings and opens the door for new applications (e.g. studying beliefs about climate change). Here, we present a deep recurrent neural network method for automatic causal explanation analysis. Also, we apply our complete pipeline for analyzing demographics in Facebook and causal explanations in Yelp reviews.

2 - Systematic Literature Review Tools: Examples in Software Engineering

Jeffrey Carver, University of Alabama, Tuscaloosa, AL, United States, carver@cs.ua.edu

Even with the increasing use of Systematic Literature Reviews (SLRs), authors still face number of barriers. These barriers increase the cost of conducting SLRs). This talk will discuss recent work on tool support for SLRs in Software Engineering (SE). The talk will first overview some of the challenges with conducting SLRs that could benefit from tool support. Then, the talk will discuss existing solutions. Finally, the talk will conclude with new work on automated analysis approaches, including machine learning and AI, to support the extraction and analysis of information during SLRs. While these experiences originate from SE, the lessons learned are relevant to other domains.

3 - Incorporating Context in Literature Based Discovery

Neil R. Smalheiser, Professor, University of Illinois at Chicago, Chicago, IL, United States, neils@uic.edu

In the Swanson ABC model of discovery, a single entity or concept that is discussed in two separate contexts can be used to link assertions to form new hypotheses. Other models of discovery also rely crucially on context: For example, a breakthrough in one field may appear to have specific or restrictive features which cause it to be neglected in other contexts. I will outline an approach to literature based discovery that employs semantic predications and analogies to infer new hypotheses. This approach employs NLP techniques to measure and handle not only the entities, concepts and relations, but their varying contexts.

4 - Bridging Non-interacting Research Communities Through Machine-guided Discovery Synthesis

Gus Hahn-Powell, Lum AI, Tucson, AZ, United States, ghp@lum.ai, Dane Bell

We align a large-scale venue-level citation network (journal A cites journal B) with a graph of millions of causal relations (X decreases Y) mined from text. The aligned graph allows us to map the dispersion of scientific findings, estimate the degree of communication taking place between research communities, and generate novel hypotheses through Swanson linking. From the citation network, we derive venue-level representations (embeddings) and use their similarity to surface chains of causal relations which bridge isolated communities engaged in complementary research.

5 - Construct Identification and Causal Mapping of the Business/Management Literature

Dikshya N. Mohanty, University of North Carolina, Charlotte, NC, United States

Discordant naming of constructs —construct identity fallacy (CIF) -is a persistent problem in synthesizing knowledge from social sciences. We propose to design a machine learning algorithm for Constructs and building a causality map to access their relationship with one another. Through the employment of REACH (Reading and Assembling Contextual and Holistic Mechanisms from Text) which is information extraction system for the biomedical domain, which aims to read scientific literature and extract causal pathways, we test detecting construct identity and building a dynamic network model using business/management scientific papers.

6 - Transfer Learning for Large Text Corpus Using Deep Machine Reading at Scale

Anusua Trivedi, Senior Data Scientist, Microsoft, Redmond, WA, United States, antriv@microsoft.com

Deep learning (DL) based Machine Reading Comprehension (MRC) algorithms assume a relevant text is already identified and given to the model, which is not realistic in building an enterprise QA system. This leads us to DL based Machine Reading at Scale (MRS). It is focused on maintaining the challenge of DL-MRC, while searching over a large resource. Building machines that can perform DL-MRS would be of great interest to enterprises. But it seems like a lot of cost to enterprises to create a custom data set as large as SQUAD to train the DL models. In this talk, we attempt to capture an existing MRS algorithm and show how transfer learning can achieve good results on a custom large target text corpus.

■ TB03

CC- Room 203

Data Mining in Complex System Diagnostics and Prognostics

Sponsored: Data Mining

Sponsored Session

Chair: Jian Guo, Lam Research, Tualatin, OR, United States

Co-Chair: Zhaojun Li, Western New England University, Springfield, MA, 01119, United States

1 - Multimodal Data Fusion in 3d Printing Quality Prediction

Weihong (Grace) Guo, Rutgers, The State University of New Jersey, Piscataway, NJ, 08854, United States, wg152@rutgers.edu

Additive manufacturing, or three-dimensional (3D) printing, is an emerging technology that enables the direct fabrication of complex shapes. The material solidification in 3D printing, however, may yield geometric shape deviation in the printed parts, which adversely affects product quality and performance. The advancement in sensing technology enables us to collect measurement data to facilitate efficient and automated quality inspection for 3D printing. The objective of this study is to develop a data fusion method that can effectively fuse the different sources of sensor data and process data to evaluate the quality of 3D-printed parts. Results show that the proposed method is effective.

2 - Functional Principal Component Analysis for Extrapolating Multi-stream Longitudinal Data

Seokhyun Chung, University of Michigan, Ann Arbor, MI, United States, seokhc@umich.edu, Raed Al Kontar

We propose a functional principal component (FPC) analysis based approach to predict the evolution of multi-stream longitudinal data for an in-service unit based on other historical units. Our approach first decomposes each stream into eigenfunctions and corresponding FPC scores. A Gaussian process prior for the FPC scores is then established based on a semi-metric measuring similarities between streams of historical units and the in-service unit. Finally, an empirical Bayesian updating strategy is derived to update the prior using real-time data obtained from the in-service unit. Strengths of the model are illustrated through numerical studies using synthetic and real-world data.

3 - ResNet-based Learning for Dimensionality Reduction in Complex System

Jiaxin Zhang

A ResNet-based isosurface learning approach is proposed for dimensionality reduction in high-dimensional complex system approximation. Conventional methods, including active subspace methods and sliced inverse regression, reduce the dimensionality through an affine/linear transformation. This work aims to extend such transformation to the nonlinear regime using reversible ResNets, which is exploited to learn the target functions' isosurfaces and approximately parameterize the isosurfaces in low-dimensional spaces. High dimensional functions and complex system model are employed for illustrating the improved approximation accuracy with the use of the nonlinear transformation.

4 - A Degradation-Based Detection Framework Against Covert Cyberattacks in SCADA Systems

Dan Li, Georgia Institute of Technology, Atlanta, GA, United States, dli352@gatech.edu, Nagi Gebraeel, Kamran Paynabar

Supervisory control and data acquisition (SCADA) systems are commonly used in critical infrastructures. However, these systems are typically vulnerable to cyberattacks. Among the different types of cyberattacks, the covert attack is one of the hardest to detect — it is undetectable when the system is operating under normal conditions. In this paper, we develop a data-driven detection framework that utilizes the degradation process of the system to detect covert attacks. We derive mathematical characteristics of the degradation signals under covert attacks for different scenarios. We verify our methodology through an extensive numerical study as well as a case study.

5 - A Prognostic Framework for Complex Engineering Systems with Multi-failure Modes

Liexiao Ding, Georgia Institute of Technology, Atlanta, GA, United States

Many systems and subsystems usually have more than one cause of failure. Therefore, in real world applications, it is important to distinguish between these different causes of failures also known as Multi-failure Modes. To address the challenges, we develop a prognostic method-ology, utilizing multi-sensor stream, to identify failure mode and then predict remaining useful life(RUL) of partially degraded systems. We propose a finite mixture of (log)-location-scale regression to model inhomogeneous sensor streams and use a grouped-penalized maximum likelihood estimator to perform sensor selection.

■ TB04

CC- Room 204

Joint Session DM/HAS: Data-Driven Healthcare Analytics

Sponsored: Data Mining

Sponsored Session

Chair: Katherine Bobroske

Co-Chair: Turgay Ayer

1 - Combining Causal Inference and Queueing Theory to Study Waiting in Emergency Department

Danqi Luo, Stanford Graduate School of Business, Stanford, CA, United States, Mohsen Bayati, Sara Kwasnick, Erica Plambeck

This work provides theoretical and empirical evidence that in an ED, the arrival of an additional low-acuity patient substantially delays high-acuity patients. To estimate the effect, we propose a temporal causal structure motivated by queueing theory to estimate the cumulative extra wait times caused by one low-acuity patient on high-acuity patients. A stylized queueing model mimicking ED operations is built to provide robustness checks for our estimation framework, moreover, under which, we provide theoretical lower bounds for the extra wait times to understand better the delaying process. Evidence from a quasi-randomization in a wait-time forecast field experiment provides insights on how to mitigate such delay.

2 - MMR Vaccination Rates and the Effect of New Information

Lida Anna Apergi, University of Maryland, College Park, MD, 20742, United States, Margret V. Bjarnadottir, John Baras, Bruce L. Golden

The MMR vaccine against measles, mumps, and rubella is administered to young children. An increasing number of parents choose not to vaccinate their children in part due to a misconception that links the MMR to autism spectrum disorders. Those concerns are not supported by scientific evidence. Nevertheless, the MMR vaccination rates have dropped in recent years, which has led to a number of measles outbreaks in the US including the extensively covered outbreak in Disneyland in early 2015. In this study, we investigate policy, economic and demographic factors that influence MMR rates in addition to the effect of the Disneyland outbreak.

3 - Continuity of Care and Primary Care Workload

Harshita Kajaria, University of Cambridge, St Edmunds College, Mount Pleasant, Cambridge, CB3 0BN, United Kingdom, Michael Freeman, Stefan Scholtes

We present a comprehensive dataset of longitudinal patient-level data from the NHS, comprising primary and secondary care usage of 5M patients registered with 300 primary care practices across the UK over the course of 10 years. We will present preliminary results on the effect of continuity of care, i.e. seeing your preferred primary care physician, on the duration and frequency of primary care appointments.

4 - Sequence Mining for the Patient Journey: Process Clustering in Claims Data

Katherine Bobroske, Cambridge Judge Business School, Trumpington Street, Cambridge, CB2 1AG, United Kingdom, kab80@jbs.cam.ac.uk, Lawrence Huan, Christine Larish

Medical and pharmaceutical claims provide a rich basis for research in healthcare operations; however, the structure and level of detail in medical claims makes it difficult to draw generalizable insights. Some work in data and process mining has clustered patients into analyzable subsets based on patient characteristics and similarities in their healthcare encounters. In this research, we investigate whether there is added value to clustering patients using the sequence of their healthcare interactions. We develop a data-driven algorithm (inspired by gene sequencing) and compare the predictive power of the resulting clusters to those obtained with more traditional approaches.

■ TB05

CC- Room 205

Mining Digital Trace Data of Online Communities

Sponsored: Data Mining

Sponsored Session

Chair: Tianjie Deng

1 - Computational Process Research: A Sequence Analytics Approach

Zhewei Zhang, Assistant Professor, University of Warwick, Coventry, United Kingdom, Zhewei.Zhang@warwick.ac.uk, Habin Lee, Youngjin Yoo, Youngseok Choi

Existing process studies generally rely on researchers' own observations and interpretations to embrace the contextual richness. Our paper introduces the computational sequence analytics as a methodological tool for process study. We argue that computational tools and theoretical ideas need to be tightly integrated, and discuss how the critical realism thinking can play important roles in such study. Based on these ideas, we propose an integrated framework, and show particularly how sequential pattern mining can be used to detect latent patterns of social changes and help to understand the underlying mechanisms.

2 - A Network Perspective on the Shaping of Routines in Open Source Software Project

Xinyu Li, Case Western Reserve University, Cleveland, OH, United States

This study seeks to extend existing knowledge on routines in open source software (OSS) projects. We propose a framework to theorize how routines in OSS contexts are shaped by a network of OSS projects. We argue that more similar routines tend to emerge between OSS projects when the projects are more related to each other in the network due to their overlapping developers. Empirically, we investigated a set of OSS projects utilizing 90,975 digital trace data. We found that the routine similarity is negatively associated with the network distance between the projects. Our findings suggest that network relations among OSS projects may be an overlooked factor that shapes routines in the projects.

3 - Customer Engagement at Fingertips: A Large-scale Field Experiment Using Tap Stream Data

Wei Chen, University of Arizona, Tucson, AZ, 85718, United States, weichen@email.arizona.edu, Karen Xie, Jiaheng Xie, Dong Jing

In this research, we aim to increase the acceptance rate of push-notification request by incorporating the engagement state of users generated from users' tap data on smartphones and machine learning algorithms. We achieve this goal in two steps: First, we use machine learning to learn the engagement state of a user with the user's click and tapping data on a mobile phone device. Second, we use the machine learning model trained in the first step to evaluate the engagement state of a user in real time, and based on that to conduct a field experiment to evaluate the effectiveness of incorporating the engagement state of the user.

4 - Use of the Word Embedding Space to Identify Pragmatic Categories, i.e., Categories Defined by Sharing Pragmatic Contexts

Aakash Saxena, University of Colorado-Boulder, Boulder, CO, 80309, United States, aakash.saxena@colorado.edu, Jintae Lee

Recently developed methods of creating a vector space of word embeddings have produced evidence that they capture similarities among words. They capture semantic similarity because semantically similar words share many contexts. They also capture pragmatic similarity for the same reason. For example, vectors of the leader and visionary words have high cosine similarity because they appear together in the same contexts, as they are related pragmatically. We propose a method that uses word vector space to identify pragmatic categories, members of each of which are closer in the space as they co-occur in many instances of a given pragmatic context, such as in evaluating leaders, services, or products.

■ TB06

CC- Room 209

Innovative Methods in Text Mining

Sponsored: Data Mining

Sponsored Session

Chair: Jiao Wu

1 - The Hierarchical Text Mining Approaches for Multilevel Online Reviews

Ying Wang, Ph.D, Northern Illinois University, Dekalb, IL, 60115, United States, ywang15@niu.edu, Jaeki Song

Although considerable studies been conducted to analyze online reviews, little research addresses the hierarchical structure of this complex unstructured data in consumer's decision-making process, which consists of an original post followed by reply posts ordered by time. This paper is to investigate online reviews with multiple levels of nesting structure - reply posts nested within original posts within products. We aim to reveal the linguistic pattern embedded in online reviews, focusing on investigating how linguistic alignment and information congruence among reviews influence prospective consumer's information processing as well as their attitudes towards reviews and products.

2 - Adapting Neural Language Models for Classifying Microblog Sentiment

Jiao Wu, Northern Illinois University, 990 Parkhill Cir, Aurora, IL, 48858, United States, Shuyuan Deng, Dong-Heon Kwak, Atish P. Sinha, Huimin Zhao

In recent years, neural language models have been widely used for sentiment classification. However, general word embeddings are not designed to capture sentiment information. This study proposes a deep learning architecture that incorporates both general word embeddings and sentiment-specific word embeddings. It has achieved state-of-the-art results in classifying sentiment of investment-related microblog messages.

3 - Friend Recommendations Based on User-generated Contents

Jiaxi Luo, Ph.D, Midwestern State University, Wichita Fall, TX, 76308, United States, jiaxi.luo@msutexas.edu

Web 2.0 technologies have made modern SNSs increasingly popular, and SNS has expanded explosively across the web. Too many new users may cause the cold start problem. Users sign up on a SNS and discover they do not have any contacts. Normally, SNSs solve it by recommending potential friends. The huge amount of UGC could provide rich data for building an accurate, extensible user model that reflects their interests, sentiments, and personalities. From the computer-supported social matching process, these attributes could influence friend matches. In this study, we develop a text analytic framework. The results show that text features could further improve recommendation performance.

4 - Clustering Clinical Trials with Text Mining

Euisung Jung, PhD, the University of Toledo, Toledo, OH, 43606, United States, Euisung.jung@utoledo.edu

The focus of the study is to cluster and summarize clinical trial information at cluster level to enhance trial search efficiency. We propose a novel method to narrow the clinical trial search space using a custom dictionary and the UMLS Semantic Network. In this study, we cluster similar clinical trials using the domain-specific lexicon and a semantic-based feature expansion technique using Unified Medical Language System (UMLS) to resolve semantic ambiguity. A hierarchical agglomerative clustering algorithm is used. We generate word n-gram features for each clusters and modify the features with the domain-specific dictionary matching process which can be used to map a patient to a cluster.

5 - How Consumers Evaluate a New Fashion Product Through Online Review Platform

Peng Li, Ph.D, Rutgers Business School Newark and New Brunswick, Piscataway, NJ, 08854, United States, peng.li.scm@rutgers.edu, Shaoqiong Zhao, Ke Liu

With the rise of social media, online review has become more and more important as an influential source of information both for the managers and consumers. Now we can utilize this new source of information to understand how consumers evaluate new fashion products. In this paper we not only examine the contents of attributes of clothing consumers value when they stay but also attempted to categorize a number of key areas by the level of importance as measured from consumers' online reviews. In addition, the text mining methodology and inverse classification help us identify the key features that are related to positive/negative overall attitudes of online consumers.

6 - How MicroFinance Empowers the Economies of Developing Countries, a Social Media Analytics Approach

Ahmed Elnoshokaty, PhD, Northern Michigan University, Marquette, MI, 49855, United States, aelnosho@nmu.edu, Mohamed Elsaied

Microfinance is a category of financial services targeted at poor individuals and small businesses who lack access to conventional banking and related services. Although microfinance empowers the economies of developing countries, microfinance challenges remain for reaching wide-scale adoption and use. This work aims to achieve a wider spread of the microfinance services through a particular emphasis on enlightening microfinance service providers with insights on factors that influence microfinance adoption derived from mining borrowers and potential borrowers concerns on Twitter.

■ TB07

CC- Room 210

Joint Session DM/Practice Curated: Data Mining Applications in Electronic Health Records

Sponsored: Data Mining

Sponsored Session

Chair: Ozgur Ozmen

Co-Chair: Olufemi Omitaomu

1 - De-identifying Clinical Notes at Scale

Ioana Danciu, Oak Ridge National Laboratory, Oak Ridge, TN, United States, Everett Rush, Edmon Begoli

Clinical notes offer invaluable insights into patients' health trajectories, but transforming the text into a research-ready form is no easy task. We present our approach to scrubbing billions of notes of protected health information (PHI) as defined by HIPAA. We used Apache Spark and worked with the National Library of Medicine (NLM) to adapt their PHI scrubber to our big data framework. The framework is generalizable to other natural language processing tasks. The results are supporting the Million Veterans Program (MVP) and are available to Veterans Affairs (VA) and Department of Energy (DOE) researchers.

2 - Aggregation and Reporting Frequencies of Healthcare Transactions to Identify Anomaly

Ozgur Ozmen, Oak Ridge National Laboratory, Oak Ridge, TN, United States, ozmeno@ornl.gov, Hilda Klasky, Karthik Rajasekar, Olufemi Omitaomu, Mohammed Olama, Laura Pullum, Teja Kuruganti

The implementation of the health IT systems has resulted in unintended consequences, often escalating to hazards in patient care. Monitoring the anomalous number of healthcare transactions is an effective way of detecting hazards. In this talk, we describe a method of aggregating clinical order transaction counts (i.e., rejections) that extracts the data from Veterans Affairs EHR system and preprocess the data by leveraging high performance slice-and-dice analytics. We present a Statistical Process Control based detector that works on the meta-data and describe a use-case that guides root cause analysis of hazards via fast data aggregations.

3 - Hazard Detection in Electronic Health Records Using Real-time Forecasting Approach

Jordan Pellett, Oak Ridge National Laboratory, Oak Ridge, TN, United States, pellett.jordan@uwlax.edu, University of Tennessee, Knoxville, TN, United States, Olufemi Omitaomu

Detecting hazardous events in Electronic Health Records (EHR) is a challenge due to the diverse and noisy contents of EHR. In this paper, we present a real-time forecasting approach to detect hazardous events in EHR streaming data. This approach uses temporal frequency of activities to characterize events. Once a hazardous event is detected, our approach suppresses its effect in subsequent time intervals; this enables the detection of new and emerging events. Experiments are performed using EHR data from the Corporate Data Warehouse of the Veterans' Affairs. Results show considerable improvement over existing hazard detection methods in most cases.

4 - Reverse-engineering Event Sequence Data from Clinical Order Transactions for Machine Learning Techniques

Hilda Klasky, Oak Ridge National Laboratory, TN, United States, Ozgur Ozmen

A common way of analyzing electronic health records is to represent them as event sequences and investigate temporal patterns. In the absence of well-defined event logs in corporate data warehouses (CDW), we needed to extract relevant information scattered among numerous tables. In this talk, we will describe the procedure applied to clinical order transactions in Veterans Affairs CDW. We extracted recorded dates columns related to status updates and represented them as time-sorted event sequences. These event sequences were leveraged for process mining techniques. We will conclude the talk with an example of how machine learning can be applied to this data to identify irregular order patterns.

5 - Online Detection of Abrupt Transitions in Electronic Health Records

Yunhe Feng, University of Tennessee, Knoxville, TN, United States, yfeng14@vols.utk.edu, Olufemi Omitaomu, Qing Cao

Abrupt transitions in data from Electronic Health Records (EHR) could suggest anomalous behavior of Health IT systems. In this paper, we present new approaches for detecting abrupt transitions in EHR data with special focus on machine-generated errors. We used the results obtained to quantify the spatio-temporal patterns of machine errors in large-scale EHR data.

■ TB08

CC- Room 211

Emerging Themes at the Intersection of Artificial Intelligence and Optimization

Emerging Topic: Artificial Intelligence & Machine Learning

Emerging Topic Session

Chair: Rahul Mazumder, Massachusetts Institute of Technology, Cambridge, MA, 02139, United States

1 - understanding Accelerated Optimization Methods via Differential Equations

Weijie Su, The Wharton School, University of Pennsylvania, Philadelphia, PA, United States, suw@wharton.upenn.edu

This talk introduces a framework that uses ordinary differential equations to model, analyze, and interpret gradient-based optimization methods. We derive a second-order ODE that is the limit of Nesterov's accelerated gradient method for non-strongly objectives (NAG-C). The continuous-time ODE is shown to allow for a better understanding of NAG-C and, as a byproduct, we obtain a family of accelerated methods with similar convergence rates. Next, we derive high-resolution ODEs as more accurate surrogates for three first-order methods. This is based on joint work with Stephen Boyd, Emmanuel Candes, Simon Du, Michael Jordan, and Bin Shi.

2 - Robustness and Generalization Guarantees for Overparameterized Neural Network Training

Mahdi Soltanolkotabi, University of Southern California, Los Angeles, CA, United States

Modern neural nets are trained in an over-parameterized regime of where the parameters exceed the size of the training dataset. These models in principle have the capacity to (over)fit any set labels including pure noise. However, somewhat paradoxically, models trained via first-order methods predict well on yet unseen test data. I will discuss some results aimed at demystifying such phenomena by demonstrating that gradient iterates: (1) converge at a geometric rate to a generalizable global optima and (2) are provably robust to noise/corruption/shuffling on a fraction of the labels with these algorithms only fitting to the correct labels and ignoring the corrupted labels.

3 - Learning Hierarchical Interactions at Scale

Hussein Hazimeh, MIT, Cambridge, MA, United States, hazimeh@mit.edu, Rahul Mazumder

In many learning settings, it is beneficial to augment the main features with pairwise interactions. Such interaction models can be often enhanced by performing variable selection under "strong hierarchy": an interaction is nonzero only if its associated main features are nonzero. We model the problem as a MIP and develop a scalable algorithm for solving it, by integrating a specialized first order method into a non-linear branch-and-bound (BnB) framework. While modern MIP solvers cannot go beyond 20,000 interactions, our open-source BnB handles 50 million interactions in minutes. Comparisons with state-of-the-art relaxations indicate considerable statistical gains from solving the MIP.

4 - Constrained Optimization in Machine Learning

Juan Pablo Vielma, Massachusetts Institute of Technology Cambridge, MA, 02142, United States, Ross M. Anderson, Chris Coey, Joseph Huchette, Lea Kapelevich, Will Ma, Christian Tjandraatmadja

While the machine learning world is dominated by unconstrained optimization models and methods, the operation research world often (or even mostly) considers constrained optimization models and methods. In this talk we consider the potential impact of constrained optimization in machine learning through two specific applications. The first application considers the use of mixed integer programming to verify robustness of trained deep neural network. The second application considers the use of advanced interior point solvers for shape constrained regression.

5 - Randomized Gradient Boosting

Rahul Mazumder, MIT, Cambridge, MA, 02142, United States, Haihao Lu

Gradient Boosting Machine (GBM) introduced by Friedman is an extremely powerful supervised learning algorithm that is widely used in practice —- it routinely features as a leading algorithm in machine learning competitions such as Kaggle and the KDDCup. In spite of the usefulness of GBM in practice, our current theoretical understanding of this method is rather limited. In this work, we propose Randomized Gradient Boosting Machine (RGBM) which leads to significant computational gains compared to GBM, by using a randomization scheme to reduce the search in the space of weak-learners.

■ TB09

CC- Room 212

Joint Session AI/Practice Curated: Machine Learning in Energy Systems

Sponsored: Artificial Intelligence

Sponsored Session

Chair: Feng Qiu, Argonne National Laboratory, Lemont, IL, 60439, United States

Co-Chair: Alinson Xavier, Argonne National Laboratory, Argonne, IL, 60439, United States

1 - Real-time Faulted Line Localization and PMU Placement in Power Systems

Deepjyoti Deka, Los Alamos National Lab, 3200 Canyon Road, Los Alamos, NM, 87544, United States

Diverse fault types, fast re-closures, and complicated transient states after a fault event make real-time fault location in power grids challenging. We present a localization method based on a Convolutional Neural Network (CNN) classifier using bus voltages. Unlike prior data-driven methods, the proposed classifier is based on features with physical interpretations that improve the robustness of its performance. Further a phasor measurement units (PMU) placement strategy is proposed to maximize the performance. A significant aspect of our methodology is that under very low observability, the algorithm is still able to localize the faulted line to a small neighborhood with high probability.

2 - Learning for Constrained Optimization by Identifying Active Constraints

Sidhant Misra, Los Alamos National Lab, Los Alamos, NM, United States

Decision making process in many energy systems involve solving similar optimization problems routinely with small variations in parameters. By using the information available in this repeated solution process, we propose to learn a model of the optimal solution as a function of the parameters. The method is based on identifying the optimal active constraints, and provides a natural way to enforce constraints while being interpret-able. A streaming algorithm is proposed to learn the relevant active sets for a given parameter distribution, and a classifier is employed to predict the optimal active set. The approach is demonstrated on the DC Optimal Power Flow problem on a large range of test cases.

3 - Modeling, Analysis and Prediction of Weather-induced Outages Using Graph Convolutional Networks

Rui Yao, Argonne National Laboratory, Lemont, IL, 60439, United States, yaorui.thu@gmail.com, Feng Qiu, Jie Chen

Adverse weather is a major threat to the security of electric power systems because it can cause widespread power outages. However, the weather-induced outages are complex in nature and are difficult to model. In this work, we demonstrate the modeling and prediction of weather-induced outages with machine learning techniques. With the real customer outage data with geographical information and the weather data records, we use the graph convolutional network (GCN) and recurrent neural network (RNN) to model the spatio-temporal interdependency of the outages under the weather influence in the power grid. We also demonstrate the prediction of weather-induced outages based on the trained models.

4 - Learning the Weather Impacts on Power System Outage

Xinda Ke, Pacific Northwest National Laboratory, Richland, WA, United States, Qiuhua Huang

In this talk, we will first give a overview of machine learning and its applications in power systems (smart grid). Then, we will present a specific case study of applying various machine learning and data analytic techniques to analyze and quantify the impacts of weather, in particular severe weather conditions, on power system outages. Our study is based on realistic power system outage data and weather data collected in the Northwest region of the U.S. over the last 20 years.

■ TB10

CC- Room 213

High Success in Practical Commercial Applications

Sponsored: Analytics

Sponsored Session

Chair: Aaron Burciaga, Analytics2Go, Tysons, VA, 22102, United States

1 - Fifteen Years of Capital Budgeting, a Literature Review of Resource Allocation Problems

Erich D. Morman, Naval Postgraduate School, Monterey, CA, 93940, United States

The capital budgeting problem is universal across all institutions. Whether examining problems of providing quality healthcare service, purchasing military assets, improving manufacturing, or investing in research and development, decision makers must make difficult choices with limited resources to determine which projects within their organization will receive funding and which projects will not. This literature survey takes a closer look at fifteen years of capital budgeting: 2004 to 2018. The research provides an examination of the most recent capital budgeting methodologies and an investigation into how current scholars are modeling the different components of capital budgeting.

■ TB11

CC- Room 214

APS Special Invited Lecture on Reinforcement Learning

Sponsored: Applied Probability

Sponsored Session

Chair: Jing Dong, Columbia University, New York, NY, 60208, United States

Co-Chair: Jamol Pender, Cornell University, Ithaca, NY, 14850, United States

1 - An Introduction to Reinforcement Learning

Benjamin Van Roy, Stanford University, Stanford, CA, 94305, United States

The reinforcement learning problem is that faced by an agent interacting with an uncertain environment aiming to maximize rewards it accumulates over time. This tutorial will introduce the problem and basic policy and value function learning algorithms that aim to address it. We will also discuss data efficiency and the role of exploration, generalized value functions, and hierarchical reinforcement learning. Experience with supervised learning, neural networks, and dynamic programming, is assumed.

■ TB12

CC- Room 2A

Learning, Optimization and Applied Probability

Sponsored: Applied Probability

Sponsored Session

Chair: Harsha Honnappa, Purdue University, West Lafayette, IN, 47906, United States

1 - Fairness Without Demographics in Repeated Loss Minimization

Hongseok Namkoong, Stanford University, Stanford, CA, 94305, United States, Tatsunori Hashimoto, Megha Srivastava, Percy Liang

Machine learning models (e.g., speech recognizers) are trained to minimize average loss, which results in representation disparity—-minority groups (e.g., non-native speakers) contribute less to the training objective and thus tend to suffer higher loss. Worse, as model accuracy affects user retention, a minority group can shrink over time. We show that empirical risk minimization (ERM) amplifies representation disparity over time, which can even make initially fair models unfair. Distributionally robust optimization controls the risk of the minority group at each time step, in the spirit of Rawlsian distributive justice, while remaining oblivious to the identity of the groups.

2 - On the Impacts of Tail Model Uncertainty in Rare-event Estimation

Henry Lam, Columbia University, New York, NY, United States, khl2114@columbia.edu

Rare-event probabilities and risk measures can be sensitive to the accuracy of the underlying input models, especially regarding their tail behaviors. We investigate how the lack of tail information of the input can affect the output extremal measures, in relation to the level of data that are needed to inform the input tail. We argue that heavy-tailed problems are much more vulnerable to input uncertainty than light-tailed problems. We explain this phenomenon via their large deviations behaviors, and substantiate with some numerical experiments.

3 - Probability Functional Descent Algorithms

Carson Kent, Stanford University, Stanford, CA, 94305, United States, Jose Blanchet, Peter W. Glynn

Many optimization and estimation problems of interest can be abstracted into a form which involves optimizing a functional over the space of probability measures on a given a domain. Examples of these formulations include variational inference, Markov decision processes, and optimal transport costs. We present gradient descent algorithms which are shown to achieve fast convergence guarantees for these problems. Our results include duality results of independent interest which have implications in the context of distributionally robust optimization.

4 - Risk-sensitive Inference

Harsha Honnappa, Purdue University, West Lafayette, IN, United States, honnappa@purdue.edu, Prateek Jaiswal, Vinayak Rao

We consider a single-stage stochastic optimization problem, where the stochastic variable is only known through a parametrized predictive model. Operating in a Bayesian setting, we study the interplay between posterior estimation and decision-making through a “risk-sensitive” lens by leveraging dual representations of convex risk measures. We prove finite sample probabilistic bounds on an oracle regret function and illustrate these results through simulations on an example problem. Time permitting, we will discuss extensions of the methodology to non-Bayesian and multi-stage problems.

■ TB13

CC- Room 2B

Data-driven Problems in Mathematical Finance

Sponsored: Applied Probability

Sponsored Session

Chair: Mykhaylo Shkolnikov

1 - Optimal Dynamic Futures Portfolios

Yang Zhou, University of Washington, Seattle, WA, 98105, United States, Tim Leung

We study the problem of dynamically trading a portfolio of futures contracts under a number of stochastic multi-factor models. A utility maximization approach is developed to determine the optimal futures trading strategies. Applications to volatility and oil futures are discussed.

2 - Interpretable Sparse Proximate Factors for Large Dimension

Markus Pelger, Stanford University, Stanford, CA, 94305, United States, Ruoxuan Xiong

This paper approximates latent statistical factors with sparse and easy-to-interpret proximate factors. Latent factors in a large dimensional factor model can be estimated by principal component analysis, but are usually hard to interpret. By shrinking factor weights, we obtain proximate factors that are easier to interpret. Proximate factors consisting of 5-10% of the cross-section observations with the largest absolute weights are usually sufficient to almost perfectly replicate the population factors, without assuming a sparse structure in loadings. We provide analytical asymptotic bounds for the correlation of proximate factors with population factors based on extreme value theory.

3 - Conditional Importance Sampling for Event Timing

Alex Shkolnik, UCSB, UCSB, Santa Barbara, CA, United States

This article develops a conditional important sampling (IS) for a wide range of stochastic point process models of event counting processes. We contribute to the event timing simulation literature by designing, implementing and testing a simple and practically efficient IS scheme for tail probabilities. Our approach to the design of the scheme is nontrivial and is of independent interest. Numerical results demonstrate its application to estimating rare-event probabilities and pricing interest rate derivatives with efficient performance. Joint work with Baeho Kim.

4 - The Gorin-Shkolnikov Identity and its Random Tree Generalization

David Clancy, University of Washington, Seattle, WA, United States

The recent work of Gorin and Shkolnikov (2018) have shown the area under normalized Brownian excursion minus half the integral of its total local time squared is a centered Gaussian with variance 1/12. Hariya (2016) gave a path-wise proof of the same result. Gaudreau Lamarre and Shkolnikov (2017) generalized this to reflected Brownian bridges and asked for a combinatorial interpretation. We provide a combinatorial interpretation as the limit of the difference of two quantities on random forests on n nodes. We further generalize this to other forest models outside of a Brownian setting.

■ TB14

CC- Room 302

Empirical Studies in Operations Management

Sponsored: Manufacturing & Service Oper Mgmt

Sponsored Session

Chair: Seyed Emadi

1 - Menu Costs and the Bullwhip Effect: Supply Chain Implications of Dynamic Pricing

Robert Louis Bray, Kellogg School of Management, Northwestern University, Evanston, IL, 60202, United States, r-bray@kellogg.northwestern.edu

We study the supply chain implications of dynamic pricing. Specifically, we estimate how reducing menu costs—-the operational burden of adjusting prices—-would affect supply chain stability. We estimate that removing menu costs would stabilize the supply chain by attenuating order batching. Specifically, we estimate that removing menu costs would cut the average batch size by 5.0%, which would decrease the average standard deviation of orders by 3.9%

2 - Machine Learning in Demand Estimation with Long Tail Data

Fanyin Zheng, Columbia University, Columbia Business School, 412 Uris Hall, New York, NY, 10027, United States, Pu He

Discrete choice demand estimation is an important tool of empirical studies in operations management, economics, and marketing. The most commonly adopted framework is introduced by Berry, Levinsohn, and Pakes (1995, BLP). One disadvantage of BLP is that it exhibits major limitations when the customer choice data has long tails-i.e., when many products and services offered have zero demand or very low demand at a given period of observation. In this paper, we show that the common practice of dropping products and services with zero and low sales introduces substantial bias in BLP estimates. We propose a solution to correct for the bias using a two-stage estimator.

3 - An Empirical Study of Caller Behavior under a Callback Option

Brett Hathaway, UNC Chapel Hill, Chapel Hill, NC, 27514, United States, brett_hathaway@kenan-flagler.unc.edu, Seyed Emadi, Vinayak V. Deshpande

While call centers have recently invested in callback technology, the impact of this innovation on caller behavior and call center performance is not clearly understood. Using call center data from a US commercial bank, we perform an empirical study of the callers’ decision-making process in the presence of a callback option.

4 - Intended and Unintended Consequences of Drug Price Regulations

Andrew Wu, Assistant Prof of Technology, Operations, Finance, Ross School of Business, University of Michigan, Ann Arbor, MI, United States, andydiwu@umich.edu, Jun Li

To curb rising drug prices, regulators in many countries have implemented, or plan to implement, various forms of price regulation, including mandated price ceilings for individual drugs. We exploit a major policy shift in the Chinese pharmaceutical market — the elimination of longstanding ceilings on retail drug priciest — to examine the impact of price regulations on drug prices. We find that overt drug price regulation, such as price ceilings, could lead to the unintended consequence of inflated prices, potentially due to asymmetric information and focal point pricing.

■ TB15

CC- Room 303

MultiCriteria Group Decision Making Models

Sponsored: Group Decision Making and Negotiation

Sponsored Session

Chair: Adiel Teixeira De Almeida, Universidade Federal de Pernambuco, Recife PE, 50630-970, Brazil

Co-Chair: Danielle Morais, Universidade Federal de Pernambuco, Recife - PE, 52020-212, Brazil

1 - Modeling Social Distance and Altruism in Systems of Shared Mobility as a Multi-Criteria Decision Problem

Dmitry Gimon, Park University, Parkville, MO, United States, dmitry.gimon@park.edu

Shared mobility systems allow people to increase the efficiency of infrastructure use. We consider shared infrastructure use as a complex collective decision problem, where users make decisions on how to use the system. Altruism drives individuals to act in the interest of others. In this study, we modeled individual decision making as a multi-criteria problem. We applied a model of altruism as a function of the social distance between the users in order to study the benefit of connecting shared mobility users to each other. As a decrease in social distance results in increases of altruism, we studied how this change affects the efficiency of sharing. We used simulations to test the proposed model.

2 - A Multicriteria Group Decision Approach to Define Maintenance Policies under Resource Constraints

Alexandre Alberti, Brazil, alexandre.emc091@gmail.com, Cristiano Cavalcante, Danielle Morais

We present a group decision approach for the definition of maintenance policies in contexts involving multiple sectors, which share the resources available for asset maintenance. Each sector has its specific characteristics and operating requirements and is represented by a decision maker (DM), who considers the criteria that he deems pertinent to make decisions on maintenance. However, the amount of resources for maintenance may be a constraint to maximizing all the DMs' satisfaction, and then we present an approach that can be used to seek better solutions for the group as a whole.

3 - Applying VFT and Fitradeoff for Multicriteria Group Decision Making in the Context of Brazilian Federal Police Operational Activities

Carla P. Cunha, Universidade Federal de Pernambuco, Recife, Brazil, cunhacarla1976@gmail.com, Caroline Miranda Mota, Adiel Teixeira De Almeida, Eduarda Frej

Under an investigative aspect, the duties of Brazilian Federal Police are innumerous. In this context, considering that the driving force of the decision-making process should be the set of organizational values, this work intends to demonstrate the significant decision support that may come from the application of the Value-Focused Thinking (VFT) method in the identification of values and objectives of the Federal Police and subsequent application of the FITradeoff method for multicriteria group decision making (MCGDM), in order to make the judicial police of the Federal Union more efficient.

4 - Multicriteria Group Decision Making (MCGDM) Processes with Flexible and Interactive Tradeoff Elicitation

Adiel Teixeira De Almeida, Universidade Federal de Pernambuco, Recife PE, 50630-970, Brazil, Eduarda Frej, Lucia Reis Peixoto Roselli

A decision support system is presented for MCGDM with FITradeoff method, which uses partial information for criteria aggregation by an additive model in MAVT scope. For choice, it explores potential optimal alternatives. For ranking, it searches for dominance relations between alternatives. The DSS presents flexibility to help agreements about the best alternative for the group of DMS. The process is enhanced by using graphical visualization, whose design has been improved by using neuroscience experiments, which also produces insights for the analyst when interacting with DMs. The DSS is easily available at www.fitradeoff.org and has been applied in many situations.

■ TB16

CC- Room 304

New Models in Services and Sharing Economy

Sponsored: Manufacturing & Service Oper. Mgmt/Service Operations

Sponsored Session

Chair: Luyi Yang, Johns Hopkins University, Baltimore, MD, 21202, United States

1 - Ride Solo or Pool: Designing Price-service Menus for a Ride-sharing Platform

Jagan Jacob, University of Rochester, Simon Business School, Rochester, NY, 14627, United States, Ricky Roet-Green

A ride-sharing platform (RSP) such as Uber or Lyft, can sometimes offer passengers an option to share (pool) the ride with fellow passengers. On the one hand, a passenger who pools benefits from paying a lower fare and the RSP benefits from increasing occupancy-per-car, thereby serving more passengers. On the other hand, a passenger who pools takes more time on average to reach her destination and may have to share the ride with a stranger, and the RSP gets a lower profit margin per passenger compared to solo rides. We develop a queueing model to find the RSP's optimal revenue at equilibrium when passengers are strategic and drivers are independent agents.

2 - A Queueing Model and Analysis for Autonomous Vehicles on Highways

Neda Mirzaeian, PhD Candidate, Carnegie Mellon University, Pittsburgh, PA, 15217, United States, mneda@andrew.cmu.edu, Soo-Haeng Cho, Alan Scheller-Wolf

Autonomous vehicles (AVs) have a potential to significantly improve highway congestion, since these vehicles are able to maintain smaller inter-vehicle gaps, and travel together in larger platoons (or batches) than human-driven vehicles (HVs). We model a multi-lane highway segment as a queueing system, and analyze two policies: the designated-lane policy (designating one lane to AVs) and the integrated policy (allowing both AVs and HVs in any lane). After calibrating our model to data, we compare the performance of these two policies that depend on the proportion of AVs and the highway load.

3 - Economic Behavior of Information Acquisition: Impact on Peer Grading in Moocs

Dongyuan Zhan, University College London, School of Management, Gower Street, London, WC1E 6BT, United Kingdom, d.zhan@ucl.ac.uk, Onesun Steve Yoo

A critical issue in operating Massive Open Online Courses (MOOCs) is the scalability of providing feedback. Since it is infeasible for instructors to grade large number of students' assignments, MOOCs employ peer-grading systems. We investigate how the economic behavior of student graders impacts the accuracy of peer grading. We characterize grading as the process of acquiring information about the quality of the assignment, present the economic tradeoff facing each student grader, and analyze the unique equilibrium grading behavior of a homogeneous group of students. We identify the condition under which peer grading fails, namely when each grader submits uncorrelated grades in equilibrium.

4 - Invite Your Friend and You'll Move Up in Line: Optimal Design of Referral Priority Programs

Luyi Yang, Johns Hopkins University, Baltimore, MD

This paper studies the optimal design of referral priority programs, in which customers on a waitlist can jump the line by inviting their friends to also join the waitlist. Recent years have witnessed a growing presence of referral priority programs as a novel customer acquisition strategy for firms that maintain a waitlist. Different variations of this scheme are seen in practice, raising the question of what should be the optimal referral priority mechanism. We build an analytical model that integrates queueing theory into a mechanism design framework, where the objective of the firm is to maximize the system throughput, i.e., to accelerate customer acquisition. Our analysis shows that the optimal mechanism has one of the following structures: full-priority, partial priority, first-in-first-out (FIFO), and strategic delay.

■ TB17

CC- Room 305

Joint Session MSOM ServOps/Sharing Economy: Pricing and Matching for Marketplaces

Sponsored: Manufacturing & Service Oper. Mgmt/Service Operations

Sponsored Session

Chair: He Wang, Georgia Institute of Technology, Atlanta, GA, 30332-0205, United States

1 - Pricing for Online Truckload Shipping Platforms

Yufeng Cao, Georgia Institute of Technology, Atlanta, GA, 30080, United States, yufeng.cao@gatech.edu, Anton J. Kleywegt, He Wang

Recent startups are moving truckload brokerage online and smooth the matching process with technology innovation. Nevertheless, challenges exist for these online truckload matching platforms: (a) randomness on both sides of the market; (b) limited control over the resource.

Our study explores operations management problems in these platforms and provides new managerial insights on two-sided marketplaces. We propose a mathematical model that captures stochastics on both sides of the market. We study the optimal pricing policy in different settings and develop heuristics to achieve near-optimal performance. We also suggest ways to improve matching outcomes in these platforms.

2 - Optimal Service System Design with Flexible Servers and Priority Customers

Xuan Wang, Hong Kong University of Science and Technology, School of Business and Management, LSK 4079, Kowloon, Hong Kong, xuanwang@ust.hk, David Chen, Ruoran Chen, Rowan Wang

We study a non-preemptive service system with two priority classes and two flexible servers with heterogeneous service rates. We give a complete characterization of the optimal service policy for this system, which is a threshold type with strategic idling. We develop an algorithm to compute the optimal thresholds that minimize the long-run average waiting cost. In comparison to a benchmark policy where a dedicated server is assigned to customers with a higher priority, we find that the optimal policy in our proposed flexible configuration always performs better in terms of the long-run average waiting cost as well as the probability that a new arrival has to wait for both classes of customers.

3 - Robust Online Resource Allocation: a Competitive Analysis of Service Reservations with Heterogeneous Types

Jinglong Zhao, Massachusetts Institute of Technology, 77 Massachusetts Avenue, Cambridge, MA, 02139, United States, Will Ma, David Simchi-Levi

Our model is motivated by an industry partner's supply chain. A manufacturing plant, having some initial stock capacity, receives a sequence of orders which request some fraction of that stock. The plant must decide whether to fulfill the order using its stock, or reject it. Orders cannot be split and if there is not enough stock left to fulfill the entire order size, then the order must be rejected. The plant is trying to maximize its final utilization. We propose a randomized threshold policy, which has a 0.432-competitive ratio on a single knapsack. We further generalize our results to multiple knapsacks.

4 - Dynamic Pricing in Two Sided Queuing Systems

Sushil M. Varma, PhD Student, Georgia Institute of Technology, Atlanta, GA, United States, sushil@gatech.edu, Pornpawee Bumpensanti, Siva Theja Maguluri, He Wang

We studied two-sided queuing systems in which, unlike the traditional queuing systems, customers and server both arrive and wait in the queue until they are matched. As soon as a customer is matched with a server, they leave the system and the service is assumed to be complete instantaneously. We make the system positive recurrent by employing the idea of dynamic pricing. We formulated our system as an average cost Markov decision process to maximize the revenue earned by the system operator. We proved some structural properties of the pricing policies and extended these ideas to a system with multiple types of customers and servers.

■ TB18

CC- Room 306

Empirical Studies in Operations Management

Sponsored: Manufacturing & Service Oper. Mgmt/Supply Chain

Sponsored Session

Chair: Serguei Netessine, The Wharton School, Philadelphia, PA, 19104, United States

1 - Do Performance Nudges Work for Driving Performance? Evidence from A Field Experiment

Vivek Choudhary, INSEAD Business School, Singapore, vivek.choudhary@insead.edu, Masha Shunko, Serguei Netessine

Can non-monetary interventions improve driving behavior when real-time feedback with monetary incentives fail (Choudhary et al. 2018)? Conducting a randomized field experiment with >1050 drivers, we investigate this question. Using a telematics smartphone application, we provide real-time feedback to the drivers and nudge them to improve. We use three types of performance nudges - personal best, personal average and latest score nudge. Our results show that not all types of nudges work. Personal best and average performance nudges found to be more effective. Our work contributes to the literature by providing evidence that a costless intervention can be effective in changing behavior.

2 - When the Crowd Grows Restless: Managing Interventions on Crowdfunding Platforms

Philipp Benjamin Cornelius, Rotterdam School of Management, Mandeville Building T09-10, Burgemeester Oudlaan 50, Rotterdam, 3062 PA, Netherlands

Crowdfunding has become a cornerstone of entrepreneurial finance, but it also exposes companies to significant reputational risk from crowds that quickly turn hostile if they feel ignored or if the campaign does not progress as expected. Companies have several options to intervene in such cases, however certain interventions can aggravate the situation while others are costly. We empirically study the efficacy of different intervention strategies.

3 - Decoupling Learning Rates Using Empirical Bayes

Sareh Nabi, University of Washington, Seattle, WA, United States, snabi@uw.edu

Two often-faced challenges in Management Science applications are the absence of informative priors, and the inability to control parameter learning rates. We propose an Empirical Bayes approach that addresses both challenges. Our method learns empirical priors from data itself and uses them to decouple the learning rates of any feature grouping in a Generalized Linear Model. We apply our method to a standard optimization problem as well as an online combinatorial optimization problem in a contextual bandit setting in an Amazon production system. Our method shows marked improvements, especially in cases of small traffic and can be applied to any problem instance modeled as a Bayesian framework.

4 - Inconvenience, Liquidity Constraints, and the Adoption of Off-grid Lighting Solutions

Serguei Netessine, The Wharton School, Philadelphia, PA, Bhavani Shanker Uppari, Ioana Popescu, Rowan P. Clarke'

A significant proportion of world's population does not have access to grid-based electricity, and so relies on off-grid lighting solutions. Rechargeable bulb technology is becoming prominent as an alternative off-grid-lighting model in developing countries. In this paper, we explore the consumer behavior and the operational inefficiencies that result under this model. Specifically, we are interested in measuring the impact of inconvenience (of travel to recharge the bulb) {which is a peculiar feature of this model {along with the impact of liquidity constraints on bulb usage. We also discuss the efficacy of strategies that address these factors.

■ TB19

CC- Room 307

Supply Chain Bargaining

Sponsored: Manufacturing & Service Oper. Mgmt/Supply Chain

Sponsored Session

Chair: ZHUO Feng, Dalian University of Technology, Dalian, 116024, China

1 - Negotiation in Competitive Supply Chains: The Kalai- Smorodinsky Bargaining Solution

Yuanchen Li, Purdue University, 2192 Tortuga Lane, West Lafayette, IN, 47906, United States, li1820@purdue.edu, Qi Feng, J. George Shanthikumar

We study bargaining in a two-tier supply chain with supply or retail competition. We allow the negotiations to be parallel or sequential. We also distinguish the situation with contingency from those without. Compared to previous studies in which the Nash bargaining solution is widely applied, we adopt an alternative solution, the Kalai-Smorodinsky (KS) bargaining solution, and establish its connection to the Nash bargaining solution. We observe that the Nash solution may not be appropriate for the studies involving channel competition and contingency terms. The KS solution generally grants the retailer more bargaining power, except for the case of the sequential bargaining with contingency.

2 - Coordinating Stochastic Projects Through Bilateral Negotiations

Chengfan Hou, Tsinghua University, Beijing, 100084, China, Mengshi Lu, Tianhu Deng

Project outsourcing has been a pronounced trend in many industries, but is also recognized as a major cause for project delays. We study how companies can coordinate outsourced projects with uncertain completion times through bilateral contract negotiations. We model project contract negotiations as a multi-unit bilateral bargaining game and derive the conditions such that bilateral negotiations can achieve system coordination. Our study uncovers how the coordination of project outsourcing is impacted by the contract form, bargaining power structure, network topology, and payment timing and highlights the importance of bargaining modeling in project contracting.

3 - A Nash Bargaining Framework in Public-Private Partnerships

Zhuo Feng, Dalian University of Technology, Dalian, 116024, China, zhfeng@dlut.edu.cn, Shiliang Cui, Yiwen Zhang

Public-private partnerships (PPPs) are widely used for infrastructure projects in developing countries. Under PPP, a private company finances and constructs a government project for a share of the later operating revenue of the project in return. We propose a Nash bargaining framework in PPPs which is missing in the existing literature, despite the fact that the government and the private company almost always carry out negotiations for PPP contracts.

4 - Strategic Inventories in Supply Chains with Bargaining

Lucy Gongtao Chen, Associate Professor, National University of Singapore, Singapore, bizcg@nus.edu.sg, Weijia Gu, Qinshen Tang

We investigate the existence and effect of strategic inventories for a supply chain under a bargaining framework and compare the results to those under a Stackelberg game. We then introduce supply chain competition into the system and study how the impact of strategic inventories changes. We find that while bargaining can eliminate the existence of strategic inventories, the competition between supply chain may reintroduce strategic inventories.

■ TB20

CC- Room 308

Going Beyond the Beer Game: Collaborative & Competitive Supply Chain Simulations

Sponsored: Education

Sponsored Session

Chair: Yao Zhao, Rutgers University, Newark, NJ, 07102-1895, United States

Co-Chair: Kwon Gi Mun, Fairleigh Dickinson University, Fort Lee, NJ, 07024, United States

1 - The Flower Game - Online Collaborative and Competitive Supply Chain Simulation

Yao Zhao, Rutgers University, SCMMS Department, Newark, NJ, 07102-1895, United States, yaozhao@business.rutgers.edu

Beer game ignores the conflict of interest among trading partners and the resulting delusion and conspiracies. We design a flower game to simulate multiple competing supply chains where firms in each supply chain must collaborate to win the competition, meanwhile defend themselves against their worst enemy: their partners.

2 - Hunger Chain Simulation – A Competitive Gaming for Supply Shortages

Kwon Gi Mun, Fairleigh Dickinson University, Fort Lee, NJ, 07024, United States, kwongimun@gmail.com

Action-based simulation, named as Hunger Chain Simulation, is developed for allowing students to learn Inventory Management actively by doing. Instructor can keep students engaged and can deliver OM/SCM concepts and principles effectively to the classroom. We discuss the interactive teaching materials and the effectiveness of it to allow students to practice principles and skills.

■ TB21

CC- Room 309

Learning and Strategic Incentives

Sponsored: Manufacturing & Service Oper. Mgmt/iFORM

Sponsored Session

Chair: Jussi Keppo, National University of Singapore, Singapore, 119245, Singapore

1 - Delegated Testing of Design Alternatives

Jochen Schlapp, Frankfurt School of Finance & Management gGmbH, Adickesallee 32-34, Frankfurt am Main, 60322, Germany

Design testing is an integral part of any new product development initiative as it enables firms to identify the best possible designs for their new products. The desired testing results are typically collected by (teams of) experts who need to be incentivized to not only exert effort in testing their designs, but also to truthfully reveal their findings. But how many of these experts should a firm employ, and how should the firm orchestrate their efforts? Our analysis establishes the firm's optimal testing strategy as well as the optimal incentive structures, and it also reveals how exactly delegation distorts the firm's testing process.

2 - Knowledge Sharing and Learning among Smallholders in Developing Economies: Implications, Incentives, and Reward Mechanisms

Shihong Xiao, University of Minnesota, Minneapolis, MN, United States, xiaosh@umn.edu, Ying-Ju Chen, Christopher S. Tang

Recently, knowledge-sharing platforms emerge to facilitate knowledge exchange among smallholders so as to enhance farmers' productivity. Putting altruism aside, we examine economic implications for farmers to share knowledge with others under (implicit) competition. We find that farmers with high knowledge are reluctant to share, and consequently the voluntary sharing level is suboptimal in maximizing farmer welfare. In view of the inadequacy of knowledge sharing, we propose a quota-based reward mechanism that can entice farmers to share more knowledge voluntarily, maximizing farmer welfare.

3 - Strategic Reviews

James Siderius, Massachusetts Institute of Technology, Cambridge, MA, 02134, United States, Mohamed Mostagir, Asuman Ozdaglar

Reviewers on online platforms (e.g. Yelp) can exert considerable influence on the decisions of future buyers. This can create perverse incentives for a business to offer influential reviewers side payments ("bribes") in exchange for favorable reviews. While accepting bribes increases the direct payoff to a reviewer, it imposes the cost of potentially damaging her reputation and losing sustained influence. We study the equilibrium properties of the game between reviewers and consumers and show which policies can help a platform curb the negative outcomes of review manipuation.

4 - Higher Moments of Expert Herding

Yanwei JIA, National University of Singapore, Singapore, jia_yanwei@u.nus.edu, Jussi Keppo, Ville Satopaa

Morris and Shin (2002) analyze experts' point forecasts under herding and find that increased precision of public information is not always beneficial to social welfare. We extend their model to distributional forecasts, which are common in many applications such as inflation forecasting. Our unique equilibrium is expressed in closed-form and coincides with theirs in the first moment. However, the increased precision of public information reduces the variance of experts' forecasts and improves welfare in our model. It implies that the negative welfare effect of public information disclosure does not need to exist if experts report both point forecasts and their associated uncertainties.

■ TB22

CC- Room 310

Issues in Agricultural and Food Supply Chains

Sponsored: Manufacturing & Service Oper. Mgmt/Sustainable Operations

Sponsored Session

Chair: Adem Orsdemir, University of California-Riverside, Riverside, CA, 92521, United States

Co-Chair: Eda Kemahlioglu Ziya, North Carolina State, Raleigh, NC, 27695-7229, United States

1 - The Impact of Input- vs. Output-based Farm Subsidies on Farmer Welfare and Income Inequality in Developing Economies

Ming Zhao, University of Electronic Science and Technology of China, M628, Li Ka Shing Tower, Hung Hom, Chengdu, China, Christopher S. Tang, Yulan Wang

To alleviate farmer poverty and reduce income inequality in developing economies, we study two common farmer subsidy schemes that are either input-based or output-based. By analyzing a stylized model that captures yield heterogeneity across farmers, we find that these two schemes generate different effects. First, although both types of subsidies can reduce the aggregate income inequality in terms of Gini coefficient, the input-based subsidy scheme can narrow the income gap between farmers under mild conditions, and the output-based scheme always widens this gap. Second, the low-yield farmers prefer input-based subsidies, while high-yield farmers prefer output-based subsidies.

2 - Optimal Agricultural Supply Planning under Extreme Weather Conditions

Utku Serhatli, INSEAD, Constance de le Boulevard, Fontainebleau, 77590, France, utku.serhatli@insead.edu, Andre Du Pin Calmon, Enver Yucesan

We analyze the optimal production decisions of a seed manufacturer who faces increasing incidences of extreme weather events, making its production more costly and uncertain. We propose a stochastic dynamic optimization model to describe this setting and examine the sensitivity of optimal production decisions to changes in extreme event probability and intensity. Our analysis shows that a minor increase in present or future extreme event probability can lead to major shifts in both seed production and assortment decisions. Furthermore, low-margin markets (usually developing countries) may see a significant decrease in average seed availability as extreme events become more likely.

3 - Sustainable or Not? Role of Valuation Uncertainty and Operational Flexibility in Product Line Design

Iva Rashkova, Washington University in St. Louis, St. Louis, MO, United States, Lingxiu Dong

Increasing consumer interest in healthy and eco-friendly food production (i.e., sustainability) has led food companies to rethink their product line design and strike a balance between the taste and sustainability product quality dimensions. The paper investigates the effects of uncertain consumers' willingness-to-pay for sustainability and operational costs - both R&D and production - on the firm's optimal product line length and product quality commitments. We explore the effect of the company's optimal strategy on development waste, consumer surplus and the level of investment in sustainability.

4 - Agricultural Cooperative Pricing of Premium Product

Burak Kazaz, Professor, Syracuse University, Whitman School of Management, Syracuse, NY, 13244, United States, bkazaz@syr.edu, Nur Ayvaz-Cavdaroglu, Scott Webster

We consider the problem of price setting by a cooperative for purchase of an agricultural product with the following characteristics: (1) the pricing policy is published prior to the growing season and (2) the value of the farmer's harvest is affected by his investments during the growing season. We propose two alternative pricing policies that are new to the agricultural literature, both of which can coordinate farmer decisions with the system but differ in terms of ease of implementation and susceptibility to risk aversion.

5 - Farmers Market vs. Grocery Store: A Theory of Local Food Marketplace and Food Waste

Bing Bai, Washington University in St. Louis, St. Louis, MO, United States, Lingxiu Dong

Each year twenty percent of vegetables and fruits grown in US goes to waste because of imperfect looking. Grocery stores usually have aesthetic standard to increase consumer's shopping valuation. While in farmers market, imperfect produce are generally carried. We study the effect of consumer purchasing behavior on channel competition and characterize its influence on food waste.

■ TB23

CC- Room 3A

Managing Risk and Uncertainty

Sponsored: Decision Analysis

Sponsored Session

Chair: Youngsoo Kim, University of Alabama, Tuscaloosa, AL, United States

1 - Applying A Discount Rate for Project Risk Analysis in Practice

Samuel E. Bodily, Darden School of Business, University of Virginia, Charlottesville, VA, 22903, United States, bodilys@virginia.edu

The performance of the recently-introduced adjusted discount rate ra is studied in practical project evaluation examples compared to the standard finance NPV and the correct, yet more-difficult-to-use certain return equivalent, ro. The examples studied exhibit a variety of structures of time dynamics and uncertainty. The finance approach misses some risk nuances in the varied structures although ra and ro produce similar certainty equivalent results. Because it accounts for risk preference without involving the simulation of an alternative portfolio of stocks and treasuries, ra has great promise for use in practice.

2 - Managing Multi-level, Correlated Supply Risks

Nickolas K. Freeman, University of Alabama, Tuscaloosa, AL, 35405, United States, nkfreeman@cba.ua.edu, Ming Zhao

Companies are increasingly facing the task of managing correlated supply disruption risks due to globalization and outsourcing. However, correctly estimating the correlations that prevail among available suppliers is difficult and mistakes can be costly. We consider distributionally robust models for managing supply disruption risks when suppliers are ambiguously correlated and may experience multiple disruption levels. Analysis of these models offers several insights that can help buyers determine how to direct efforts that aim to improve understanding of the prevailing correlation structure.

3 - Collaboration and Fair Labor Practices: Risk, Reputation, and Profit

Matthew J. Sobel, William E. Umstattd Professor Emeritus, Case Western Reserve University - Retired, Department of Operations, Cleveland, OH, 44106-7235, United States, matthew.sobel@case.edu, Susan A. Slotnick

The reputation and sales of a multinational buyer are hurt if its offshore supplier flagrantly violates fair labor practices. In this paper the buyer manages the reputational and financial risk of an adverse labor event at the supplier by offering the supplier financial incentives to treat its labor fairly. The underlying model of risk and reputation over time is a dynamic Stackelberg game in which the buyer has a long-run perspective while the supplier is myopic. The talk reports analytical and computational results. The buyer's risk posture plays a basic role in determining the financial incentives.

4 - Operational Risk Management: Team Based Incentive Bonus and Effort Coupling

Lingjiong Zhu, Florida State University, Tallahassee, FL, 32306, United States, lz465@nyu.edu, Yuqian Xu

We consider a financial firm that offers bonus to its employees to provide incentives to reduce operational risk losses. We characterize the optimal incentive bonus based on a team of employees, and then explore the impact of team characteristics and effort coupling among team members on the optimal bonus. We discuss when the optimal strategy is to offer bonus to one employee and when it is optimal to offer bonuses to multiple employees and present the ordering policy of the incentive bonuses. We subsequently extend our model to characterize the employees' effort coupling effect.

■ TB24

CC- Room 3B

Inaugural Flash Session II (Decision Analysis)

Sponsored: Decision Analysis

Sponsored Session

Chair: Allison C. Reilly, University of Maryland, Washington, DC, 20017, United States

1 - Should Hospitals Incentivize and Influence Physicians' Diagnostic Imaging Decisions?

Christian Wernz, Virginia Commonwealth University - VCU, Richmond, VA, 23298, United States, cwernz@vcu.edu, Aditya Umesh Kulkarni, Yongjia Song, Danny R. Hughes

Public reporting of hospital quality data intends to help patients make better consumer choices. However, this public quality signal motivates hospitals to try to achieve certain metric goals. In response, hospitals may choose to influence, incentivize or nudge physicians to change their medical decisions. We developed a decision-theoretic model to analyze the decision processes of hospitals and physicians, and explore the implications of hospitals interfering with physicians' decisions.

2 - Rumor Tracking and Strategic Decision-making During Disasters Using Supervised Machine Learning and Game Theory

Puneet Agarwal, University at Buffalo, Buffalo, NY, United States, puneetag@buffalo.edu, Kyle Hunt, Ridwan Al Aziz, Jun Zhuang

Social media is being increasingly utilized to spread breaking news and updates during disasters of all magnitudes. Unfortunately, due to the unmoderated nature of social media platforms, rumors and misinformation are able to propagate widely. Our studies investigate the interplay between rumor spreading and debunking on social media platforms using Machine Learning and Game Theory. We present an automated framework based on state-of-the-art machine learning techniques to track rumors that are spread online during disasters. We also model the strategic interactions between official agencies and social media users during rumor spreading and debunking using game-theoretic approach.

3 - Learning About and From Models: A Decision Science Approach

Michael Gerst, University of Maryland, Washington, DC, 20010, United States, mgerst@umd.edu

Models are ubiquitous in science and aiding of decision-making. Despite the frequency of their use, little progress has been made in generalizing how modelers and model users translate knowledge learned about a model to broader learning from a model. This can be a problem because (i) different scientific disciplines often use differing epistemic norms and (ii) learning consists of a chain of decisions that can be subject to cognitive biases and heuristics. We develop a framework that guides model builders and model users through the process of learning about and from a model in a way that minimizes error introduced by biases and heuristics and aids in choosing a model that maximizes learning.

4 - Cyber Deterrence OR: How We Learned to Stop Worrying and Love the Signal

Jonathan W. Welburn, RAND Corporation, Santa Monica, CA, 15213, United States, Justin Grana, Karen Schwindt

Traditional deterrence theory may not hold for cyber conflict. The cyber domain obscures actions and removes common knowledge on the ability of actors to attack, defend, & retaliate. Motivated by these features, we examine a game of deterrence between an attacker and a defender. The sequential-move game features imperfect information, uncertain attribution, and (noisy) signaling. We reveal cases where the defender can use signaling to deter an attacker. We also uncover a counter-intuitive "ant-deterrent" result that illustrates how the defender can increase its expected utility by inducing attack. The new contributions of this approach have important implications for cyber policy.

5 - Using Virtual Reality to understand Renewable Energy Preferences

Zana Cranmer, Bentley University, Waltham, MA, 02452, United States, acranmer@bentley.edu

Immersive virtual experiences can enhance the understanding of non-experts on unfamiliar topics. Building new energy infrastructure often involves interaction with the public to elicit preferences and constraints. When the public has no experience with a type of power plant, like a wind turbine, expressing preferences can be difficult. Providing an immersive, virtual experience with a wind turbine may help respondents better gauge and express their opinions about such facilities. This is especially important for wind energy, which is often subject to myths and misinformation.

6 - Ecosystem-scale Selenium Modeling and Decision Making

Karen Jenni, U.S. Geological Survey, Wheat Ridge, CO, 80033, United States, kjenni@usgs.gov

Modeling the environment is at the core of environmental laws that regulate the mining industry. USGS modelers have developed mechanistic models of the responses of ecosystems to geologic sources of Selenium exposed by ground disturbances such as mining activities. We propose here an integrated strategy that encompasses current mechanistic knowledge, modeling ability, and templates for decision-making to resolve questions related to site-specific Se protection as mining areas continue to expand and ecosystems are altered.

7 - Enabling Preemptive Planning and Increased Community Resilience through Post-Disaster Temporary Housing Decision Analysis

Daniel Perrucci, Graduate Researcher, Vanderbilt University, Nashville, TN, United States, daniel.v.perrucci@vanderbilt.edu, Hiba Baroud

Over the last three decades, the severity and frequency of natural disasters has experienced an increasing trend which drives the post-disaster displaced populations to unprecedented levels. A multi-objective decision analysis (MODA) will provide government entities the ability to analyze temporary housing alternatives in advance of the disaster displaced population. This prior planning reduces the supply chain uncertainty, and therefore, increases community resilience during the disaster recovery.

■ TB25

CC- Room 401

Prediction and Mechanism Design

Sponsored: Auction and Market Design

Sponsored Session

Chair: Michael Albert, University of Virginia, Durham, NC, 27708, United States

1 - An Equivalence Between Wagering and Fair-Division Mechanisms

Rupert Freeman, Microsoft Research, New York, NY, United States, rupert.freeman@microsoft.com

We draw a surprising and direct mathematical equivalence between the class of allocation mechanisms for divisible goods studied in the context of fair division and the class of weakly budget-balanced wagering mechanisms designed for eliciting probabilities. The equivalence rests on the intuition that wagering is an allocation of financial securities among bettors, with a bettor's value for each security proportional to her belief about the likelihood of a future event. The equivalence leads to theoretical advances and new practical approaches for both fair division and wagering.

2 - Novel Results for Multi-task Peer Prediction

Jens Witkowski, Frankfurt School of Finance & Management, Adickesallee 32-34, Frankfurt, 60322, Germany

Peer prediction mechanisms elicit private information from rational respondents without the requirement that ground truth is eventually revealed. In recent years, the peer prediction community has increasingly focused on the setting, where the center elicits reports on several questions. We present new mechanisms for this multi-task setting as well as tighter analyses of previous work.

3 - Finite Properties for Scoring Rules and Mechanism Design

Ian Kash, University of Illinois at Chicago, Microsoft Research, Chicago, IL, CB1 2FB, United States

I will discuss an application of a model of truthful elicitation which generalizes and extends mechanisms and scoring rules to understanding settings where the set of allocations (mechanisms) or reports (scoring rules) is finite. This yields a new proof of a result in mechanism design due to Saks and Yu.

4 - understanding Market Functionality and Trading Success

David Rothschild, Microsoft Research, New York, NY, 10011, United States, davidmr@microsoft.com

We examine individual-level trading data from several markets to determine what strategies correlate with financial success. Various regulations and frees limit traders to retail investors. Our data includes all orders and trades from every trader across several markets. We are able to fully reconstruct the markets and tie traders both within and between markets. We show that understanding how markets and trades works is more important to financial success than proxies for (1) confidence or funding (2) information or objectivity in trading. The work should be a call-to-action in simplifying trading for exchanges, their markets and contracts, aimed at retail investors.

5 - Minimum Revenue Socially Efficient Mechanisms under Correlated Valuations

Michael Albert, University of Virginia, Charlottesville, VA, 27708, United States, albertm@darden.virginia.edu

In many situations of interest there is a shared resource that needs to be distributed fairly to agents that have private information about their value of that resource. Traditionally, this is distributed using an auction based mechanism requiring payments. In some situations (such as in federated server farms), there is no natural party to receive payments, and therefore, these mechanisms cannot be implemented leading to a loss in social welfare. In this work, we demonstrate how to take advantage of correlation in bidder behavior in a repeated setting to learn mechanisms with zero expected payments for all participants by learning the optimal, minimum revenue mechanism.

■ TB26

CC- Room 4C-1

E-commerce

Contributed Session

Chair: Zhijun Zheng, Xi'an Jiaotong University, Xi'an, 710049, China

1 - The Impact of Social Interaction on Live-streaming Shopping

Xiabing Zheng, University of Science and Technology of China, Hefei, China, Jinqi Men, Xiao Shi

Social interaction (electronic word of mouth and observational learning) is an essential factor for the success of online commerce. The new technology of live streaming has changed how social interaction affects consumers. This study investigates how electronic word of mouth and observational learning influence consumers' perceptions on live-streaming shopping platforms. In addition, this study views consumers' perception (individuals' relationship bonding) as dynamic factor. The results of this study will contribute towards IS literature by understanding social interaction and its effect on consumers' perceptions and behavior in live-streaming shopping context.

2 - Analyzing Travel Behavior Impacts of Automated Vehicles and Mobility Services

Parastoo Jabbari, University of Washington, Seattle, WA, United States, jabbari@uw.edu, Andisheh Ranjbari, Don MacKenzie

In this study, we explore how automated vehicles may affect travel behavior in the future, particularly as self-driving vehicles are deployed in mobility-as-a-service fleets. We collected data through stated preference experiment that was designed based on each respondent's typical workday in real-time. Through several discrete choice models, impacts of different factors on users' decision making and choices (e.g. mode choices and car ownership decision) and the trade-offs users make between different factors were quantified.

3 - Inside the Learning Curve: The Mediating Role of Technological and Procedural Knowledge in High-tech After-sales Services

Fêdde S. Zijlstra, Eindhoven University of Technology, Eindhoven, Netherlands, f.s.zijlstra@tue.nl, Alex Alblas, Fred Langerak

By providing after-sales services, high-tech firms can learn about their products, services, and customers. The question is, through what mechanisms does after-sales experience impact performance? Based on 10 years of data from a high-tech firm we demonstrate how the creation of technological and procedural knowledge act as learning mechanisms. Specifically, we open the black box of the learning curve, by testing the mediating effects of technological and procedural knowledge. These findings contribute to a better understanding of learning in after-sales services.

4 - Supplementary Service Strategy of Online Marketplace: Authorized Service or Un-authorized?

Zhijun Zheng, Xi'an Jiaotong University, Xi'an, China, zhengzhijun@stu.xjtu.edu.cn, Gang Li

Supplementary services that support the core product are becoming important in consumers'purchasing decisions. In this paper, we explore the service strategy for the online marketplace, as well as the sellers. Three kinds of services, third-party authorized service (TAS), marketplace self-built authorized service (SAS), and the unauthorized service(UAS) are addressed. We find that when the commission rate of the marketplace is low (high), the seller will provide TAS (UAS). Besides, we show that the marketplace tends to provide SAS rather than TAS when the commission rate is too low or too high. The seller's price of product bundled with TAS (SAS) increases (decreases) with the commission.

■ TB27

CC- Room 4C-2

Decision Problems in Sharing-economy

Sponsored: Service Science

Sponsored Session

Chair: Zhiwei Qin, DiDi Research America, Walmart Labs, Mountain View, CA, 95117, United States

1 - Optimal Dynamic Matching with Impatient Demand and Patient Supply

Yun Zhou, McMaster University, 1280 Main Street West, Hamilton, ON, L8S 4M4, Canada, zhouy185@mcmaster.ca, Zhiyuan Chen, Ming Hu

We consider a centralized platform's problem of dynamically matching heterogeneous types of impatient demand and patient supply. Demand and supply types are vertically differentiated with either high or low-quality level. We characterize the structure of the optimal matching policy for maximizing the long-run average matching rewards minus holding costs and also explore exact and approximate methods to compute the solution. We also compare the centralized matching system with its decentralized counterpart.

2 - A Deep Value-network Based Approach for Multi-driver Order Dispatching

Zhiwei (Tony) Qin, DiDi Research America, Mountain View, CA, 95117, United States, Xiaocheng Tang, Fan Zhang, Zhaodong Wang, Zhe Xu, Yintai Ma, Hongtu Zhu, Jieping Ye

In this work, we propose a deep reinforcement learning based solution for order dispatching and we conduct large scale online A/B tests on DiDi's ride-dispatching platform. To improve the stability of the value iteration with nonlinear function approximators, we propose Cerebellar Value Networks (CVNet) with a novel distributed state representation layer. We further derive a regularized policy evaluation scheme for CVNet that penalizes large Lipschitz constant of the value network for additional robustness against adversarial perturbation and noises. Finally, we adapt transfer learning to CVNet for increased learning adaptability and efficiency across multiple cities.

3 - Where to Find Next Passengers on E-hailing Platforms? A Markov Decision Process Approach

Zhenyu Shou, Columbia University, Columbia University, New York, NY, 10027, United States, zs2295@columbia.edu, Sharon Di, Jieping Ye, Hongtu Zhu, Hampshire Robert

E-hailing drivers exhibit different behaviors from traditional taxi drivers because they do not need to actually search for passengers. This study aims to develop a Markov Decision Process model to incorporate the new behavioral characteristics of e-hailing drivers and thus derive an optimal policy. To account for the competition among drivers, a dynamic adjustment strategy of the order matching probability is devised and calibrated by using a massive dataset collected from more than 50,000 Didi drivers in Beijing. The validation results show that drivers' rate of return and the utilization rate of the vehicle can both be increased by about 10% if the driver had followed the policy.

4 - Reinforcement Learning and Optimization in Ride-sharing Dispatching Task

Fei Feng, UCLA, Los Angeles, CA, United States, fei.feng@math.ucla.edu

Ride-sharing services are significant parts of the sharing economy. To guarantee the well-functioning and profits of ride-sharing services, a good order-dispatching strategy is to be learned. We discuss several reinforcement learning approaches to attacking this problem, analyze their advantages and disadvantages, and present a new method of solving the order-dispatching task.

5 - Algorithms for Network Inventory Management

Deniz Akturk, University of Chicago, Chicago, IL, United States, akturk@chicagobooth.edu, Ozan Candogan, Varun Gupta

We consider the problem of rebalancing in a bike-sharing network. When designing our rebalancing policies, we explicitly take into account operational considerations such as the transportation, shortage, and holding costs. We provide new structural results for the rebalancing problem, and obtain policies with accompanying performance bounds. For certain network structures, we show that our policies are asymptotically optimal. We also provide numerical examples to show the effectiveness of our algorithm in rich settings.

■ TB28

CC- Room 4C-3

Smart Service Modeling, Design, and Application

Sponsored: Service Science

Sponsored Session

Chair: Robin Qiu, Penn State (The Pennsylvania State University), Malvern, PA, 19355, United States

1 - Deep Learning based Multiple-Disease Risk Predictive Modeling

Robin Qiu, Penn State (The Pennsylvania State University), 30 E. Swedesford Road, Malvern, PA, 19355, United States, robinqiu@psu.edu

This talk presents multiple disease risk predictive models to assess a discharged patient's future disease risks. We propose a novel framework that relies on deep learning techniques to substantially enhance the performance of multiple disease risk predictive modeling.

2 - Analysis of Power Grid Operation Accident Based on Causal Network Model

Chuanmin Mi, Assistant Dean, Nanjing University of Aeronautics and Astronautics, Nanjing, China, cmmi@nuaa.edu.cn, Yuanyuan Qian, Zhipeng Zhou, Qing Zhang

Internet borrowing presents different risk characteristics due to imperfect information disclosure and long tail effect. This paper constructs a network model between online lending platforms from the expected channels, and uses the SIS model to simulate the risk transmission of online lending platforms. The research results show that the network loan platform network has the characteristics of scale-free and small world, and the risk is easy to spread through the expected channels. The speed of risk transmission and the scope of transmission between the online loan platforms are affected by the risk of infection, cure rate and risk impact.

■ TB29

CC- Room 4C-4

Auctions and Market Design

Sponsored: Auction and Market Design

Sponsored Session

Chair: Martin Bichler, Technische Universitat-Munchen, Munich, 85748, Germany

1 - Computing Prices in the Product-Mix Auction

Martin Bichler, Technical University of Munich, Department of Informatics, Boltzmannstr. 3, Munich, 85748, Germany

We develop an efficient algorithm to find Walrasian equilibrium prices in multiunit, multi-item product mix-auctions in which participants express strong substitutes preferences. Our algorithms are based on DC programming,where the difference of two convex functions is minimized. We develop a DC algorithm to find global optima necessary for Walrasian prices in theproduct-mix auction and show that the problem is dual to minimizing the Lyapunov function.

2 - Combinatorial Exchanges for Transportation

Robert Day, University of Connecticut, Storrs, CT, 06269-1041, United States, Bob.Day@business.uconn.edu, Mohsen Emadikhiav

We study efficient combinatorial exchange mechanisms, proposing an electronic transportation market as a means of profitable collaboration among transportation providers (carriers) supplying to a single shipper (or single conglomeration of shippers). We propose a compact bidding language and solve the combinatorial winner determination problem optimally, influenced by practical constraints such as driver hour limitations and existing backhaul opportunities. Moreover, carriers may exchange lanes to improve allocative efficiency, in addition to typical contract procurement. We implement different payment rules to analyze the economic outcomes of this transportation market.

3 - Estimating Approximate Incentive Compatibility

Ellen Vitercik, Carnegie Mellon University, Computer Science Department, CMU, Pittsburgh, PA, 15213, United States, vitercik@cs.cmu.edu, Maria-Florina Balcan, Tuomas Sandholm

In practice, most mechanisms for selling, buying, matching, voting, and so on are not incentive compatible. We show how to estimate the extent to which an agent can improve his utility by misreporting his type, given samples from the agents' type distribution. We apply our tools to the combinatorial first-price auction, generalized second-price auction, discriminatory auction, uniform-price auction, and second-price auction with spiteful bidders. To our knowledge, these are the first guarantees for estimating approximate incentive compatibility from the mechanism designer's perspective.

4 - Markets for Information About Markets

Arnob Ghosh, Indian Institute of Technology-Delhi, Delhi, 47907, India, ghosh39@purdue.edu, Randall Berry

Motivated by the recently established recently established framework for using the 3.5 GHz band of wireless spectrum, we consider a scenario in which there is an upstream market for information (namely spectrum availability) that impacts the downstream competition among firms (i.e. wireless service providers). We consider different models for how the down-stream firms share wireless resources and different models for pricing the upstream service.

■ TB29a

CC- Room 400

Supply Chain, Humanitarian Logistics

Contributed Session

Chair: Afshin Ghassemi, University of Illinois at Chicago, Chicago, IL, 60614, United States

1 - An Approach to Identify Donor Behavior in Humanitarian Food Supply Chains

Shubhra Paul, North Carolina A&T State University, Greensboro, NC, United States, spaul1@aggies.ncat.edu, Lauren B. Davis

Humanitarian food supply chains consist of a network of donors, food bank warehouses, and agencies like soup kitchens, food pantries. These supply chains primarily function based on the goodwill of donors who provide a needed source of monetary and in-kind supplies. Donors range from individuals to retailers, farmers, and governmental entities. Contribution amounts of donors vary significantly over time in quantity, quality, and food type. We propose an approach to identify the behavioral attributes of donors and cluster them based on those attributes. We show the impact of our clustering approach by comparing the forecasts with and without donor clustering attributes considered.

2 - Facility Location Problem with Restricted Recourse

Esra Koca, Sabanci University, Istanbul, Turkey, ekoca@sabanciuniv.edu, Nilay Noyan, Hande Yaman

We study the two-stage stochastic uncapacitated facility location problems where the location and allocation decisions are made under uncertainty, while the allocation decisions may be changed in response to the realizations of the uncertain parameters. We quantify the deviations between the first and second stage allocation decisions by using a dispersion measure and control it by enforcing an upper bound on it. We devise Benders-type scenario decomposition algorithms and develop efficient methods to construct the optimal solutions of the Benders subproblems. This study is supported by the Scientific and Technological Research Council of Turkey (TUBITAK) Career Award [218M782].

3 - Optimal Design of the Hybrid Reactive Distillation System for Formic Acid Production Using Genetic Algorithm

Xiaolong Ge, Assitant. Prof. Dr., Tianjin University, Tianjin, China, g_xiaolong1@126.com, Botong Liu, Botan Liu

Hybrid reactive distillation is proposed to overcome the energy and capital intensivity in methyl formate (MF) hydrolysis production. the optimization variables of FA process includes stage number in each column sections, reflux ratios, the ratio of water and MF, the product flow rate, which turns out to be a mixed integer mathematical programming problem(MINLP). Genetic algorithm embedded in MATLAB was coupled with simulation software ASPEN plus to find the optimal solution. The energy efficiency of the process and conversion of MF could be significantly increased, while lower capital cost was achieved because of lower operating pressure in hydrolysis reaction.

4 - A New Robust Approach to Develop an Integrated Energy-water Nexus System

Afshin Ghassemi, University of Illinois at Chicago, Chicago, IL, United States, aghass2@uic.edu, Michael J. Scott

An energy-water nexus is an interconnected system including the energy subsystem, the water subsystem, and the connection between them. A new robust mixed-integer linear mathematical integrated approach is proposed to investigate the energy and water system planning. When there is a limitation on water resources, the new approach leads to lower cut-off time in comparison to the traditional separated planning approach. Moreover, the robust planning decisions provide a reliable system performance under uncertainty for demands.

■ TB30

CC- Room 6A

Tutorial: Structural Econometric Models

Emerging Topic: Tutorials

Emerging Topic Session

1 - Tutorial: Structural Econometric Models

Yong Tan, University of Washington, Seattle, WA, 98195-3226, United States, Yan Huang, Stephanie Lee

In this tutorial, we discuss the concept of structural econometric models and their applications in business and management research. Structural models are constructed by grounding on economic and related theories and attempt to accurately reflect underlying data generating processes. One unique advantage of structural models is their capability to simulate user or firm strategic behaviors under new policies and measure the effectiveness of these proposed policies, and hence generate convincing managerial suggestions. We present three representative classes of structural models: demand estimation using aggregate data, dynamic choice models, and two-sided matching models, to demonstrate model specification, assumptions, and estimation procedures.

■ TB31

CC- Room 6B

Military and Security Decision Analysis

Sponsored: Military and Security

Sponsored Session

Chair: Gregory S. Parnell, University of Arkansas, Fayetteville, AR, 72701, United States

1 - Informing Requirements and Design Through Set-based Design

Eric Specking, PhD Candidate, Univeristy of Arkansas, Fayetteville, AR, 72701, United States, especki@uark.edu, Gregory S. Parnell, Edward A. Pohl

Traditional design methods find a single “good” or several Pareto solutions to investigate further. These designs sometimes become infeasible with new information or requirement changes. Set-based design (SBD) is an alternative design method that considers a large number of alternatives and is not a new field. SBD literature lacks established quantitative techniques to define, evaluate, and selects sets. Additionally, the literature discusses the team-based component of SBD, but does not describe how to integrate it with analysis. This presentation will describe a methodology that performs and facilitates team-based SBD in early system design. An UAV case study demonstrates the methods.

2 - Supporting Efficient Resource Allocation to Mitigate Terrorist Risks During Sport Mega-events

Marcelo Zawadzki, AFIT, Wright-Patterson AFB, OH, United States, Marcelo.Zawadzki.BR@afit.edu

Sports events have proved to be a frequent target for terrorists. Protecting these events with limited resources is a challenge for security forces. The finite horizon time and the chance to heighten the security to discourage the attacker, are interesting features in this situation. We present a Stackelberg game and suggest a partially enumerative algorithm, to simplify the solution of the game. The optimal solution is guaranteed and the defense may use the algorithm to support resource allocation when trying to discourage an attack. A preliminary case study, revisiting the counterterrorism planning for the Brazilian Olympic Games, in 2016, illustrates the application of the proposed algorithm.

3 - Using Decision Analysis to Inform Agile Development Decisions

Gregory S. Parnell, University of Arkansas, Fayetteville, AR, 72701, United States, gparnell@uark.edu, Edward A. Pohl

Stage and Gate is an effective product development process when the requirements are understood. Decision analysis informs gate decisions in many domains. For many products, especially software development, the requirements become known after prototypes are provided. Agile Development was advocated as an alternative to Stage and Gates. The Agile Manifesto principles emphasize designing software that creates value for users and stakeholders. To organize the planning, agile divides the development into spirals and the spirals into sprints. We use decision analysis techniques to guide the quantification of value and risk to inform spiral and sprint decision making.

4 - A Model Centric Approach to Set-Based Design

Nicholas Shallcross, DoD/University of Arkansas, Fayetteville, AR, 72701, United States

Model based systems engineering (MBSE) methodologies offer a means to effectively and efficiently execute Set-Based Design (SBD) of complex systems in geographically dispersed organizations. We present a methodology for implementing SBD in support of complex system engineering programs to inform improved and resilient design decisions. Using Phoenix Integration’s ModelCenter® as the MBSE integration platform, we demonstrate the use of multiple variable fidelity physics and cost models in exploring, analyzing, and refining the design space as part of a multiobjective analysis of alternatives (AoA). We outline the potential benefits of our methodology and provide our future research focus.

■ TB32

CC- Room 6C

INFORMS 2019 Prize

Emerging Topic Session

Chair: Sanjay Saigal, Executive Director, MSBA, UC Davis

1 - Building Analytics Organizations - From Insights to Impact

Katie Wrenn and MaryJo Robinson, Booz Allen Hamilton, McLean, VA

Booz Allen Hamilton (Booz Allen) is one of the largest providers of analytics, data science, and machine learning services to the Federal Government, commercial institutions, and international organizations. While many early adopters agree that these capabilities have the potential to transform business or mission delivery over time, there are common challenges that organizations face that analytics and operations research leaders should understand and put into their strategies to truly scale and sustain analytics. For example: To centralize or not? How to build the right talent base? How to create a reputation and brand for technical expertise and social good? With over 4,000 practitioners, we have faced these questions for ourselves and helped clients navigate their own journeys to data-driven decision-making. In this talk, we will share our lessons learned in areas including training programs, partnerships, catalysts, and common challenges to building and sustaining a scaled analytics organization. We will also discuss how these lessons learned have translated into tangible impact for the clients we serve on a daily basis.

■ TB33

CC- Room 602

Pyomo II

Sponsored: Optimization/Computational Optimization and Software

Sponsored Session

Chair: Qi Chen, Carnegie Mellon University, PA, United States

1 - Tailored Numerical Algorithms in Pyomo with the Pynumero Extension Package

Carl Laird, Sandia National Laboratory / Purdue University, Fayetteville, AR, 47907, United States, Bethany Nicholson, Jose Santiago Rodriguez, Mary Jo Robinson

Emerging needs of science and engineering push the size and complexity of optimization problems that need to be addressed. To tackle these large-scale, but inherently structured problems, there is a need for tools that allow for rapid development of new algorithms in high-level languages without loss of computational performance. In this presentation, we will discuss the PyNumero package that provides a Python-based api for development of serial and parallel numerical optimization algorithms. We will demonstrate the ease of use and performance of this package on several parallel decomposition-based examples.

2 - Pyomo.FlexibilityAnalysis - A Modeling Framework for Optimization under Uncertainty

Maria Paz Ochoa, PhD, Carnegie Mellon University, Pittsburgh, PA, United States, Anuja Deshpande, Ignacio E. Grossmann

Pyomo.FlexibilityAnalysis is an open source Python-based modeling framework that allows the application of the flexibility analysis. In the flexibility analysis literature, many methods have been proposed. First, the vertex enumeration method, where the model is evaluated at each vertex of the uncertain parameter set. Then, the active set strategy proposes to replace the lower level of the bilevel problemt by its KKT and complementarity conditions. Recently, the dual based flexibility analysis was proposed, where the lower level problem is replaced by its dual problem. The package is a collection of modules, which contain functions that automatically apply the mentioned methods

3 - Nested Decomposition Algorithm for Large-scale Multi-period and Multistage Stochastic MIP Models

Cristiana L. Lara, Carnegie Mellon University, Pittsburgh, PA, 15201, United States, Ignacio E. Grossmann

Nested Benders Decomposition is particularly appropriate for multi-period/multistage models in which each period/node can be decomposed into a subproblem. We propose a Nested Decomposition algorithm based on Nested Benders for deterministic multi-period problems with mixed-integer recourse. Additionally, we extend the Stochastic Dual Dynamic integer Programming to also handle mixed-integer recourse in multistage stochastic programs, and parallelize the algorithm. We test both the deterministic and the stochastic frameworks by solving a Generation Expansion Planning problem for a case study in the ERCOT region with instances up to quadrillions of variables and constraints.

4 - Advances in Pyomo.gdp: An Ecosystem for Nonlinear Disjunctive Programming Modeling and Optimization Development

Qi Chen, PhD Candidate, Carnegie Mellon University, Pittsburgh, PA, 15213, United States, qichen@andrew.cmu.edu, Romeo Valentin, Sunjeev Kale, Johnny Bates, David Esteban Bernal, Michael Lee Bynum, John Siirola, Ignacio E. Grossmann

We present new capabilities for nonlinear disjunctive programming problems formulated as Generalized Disjunctive Programming (GDP) models. Global optimization of these problems requires strategies that exploit model structure. We present a new nonlinear disjunctive B&B solver, GDPbb, and an interface to the Z3 SMT solver to screen node feasibility. We introduce a global variant of the logic-based outer approximation solver GDPopt. GDPopt calls upon the MC++ toolset to construct rigorous affine cuts. GDPopt also exploits logical structure for range reduction in disjunctive scopes. We demonstrate these solution strategies with a GDP model test library alongside traditional MINLP solvers.

■ TB34

CC- Room 603

Recent Advances in Mixed-integer Optimization

Sponsored: Optimization/Integer and Discrete Optimization

Sponsored Session

Chair: Andres Gomez, University of Pittsburgh, Pittsburgh, PA, 15217, United States

1 - Intersection Disjunctions for Reverse Convex Sets

Jim Luedtke, University of Wisconsin-Madison, Madison, WI, United States, jim.luedtke@wisc.edu, Eli Towle

We present a framework to obtain valid inequalities for a reverse convex set, which is a set of points in a polyhedron that lie outside an open convex set. Intersection cuts are a well-known method for generating valid inequalities for a reverse convex set from a basic solution in the convex set. We propose a framework for deriving valid inequalities for such sets from basic solutions that lie outside the convex set. We begin by proposing an extension to intersection cuts that defines a two-term disjunction. We refer to such a disjunction as an intersection disjunction. Next, we generalize this analysis to a multi-term disjunction by considering the convex set's recession directions.

2 - Sparse Cutting Planes for Nonconvex Quadratically Constrained Quadratic Programs

Aleksandr Kazachkov, Polytechnique Montreal, Montreal, QC, Canada, Santanu Dey, Andrea Lodi, Gonzalo Munoz

Nonconvex quadratically-constrained quadratic programs (QCQPs) arise in a wide variety of real-life applications. However, interior point solvers struggle with the semidefinite programming relaxations for large instances, whereas using linear relaxations provides a scalable path forward. However, how to properly use such relaxations remains poorly understood. We investigate how to systematically incorporate sparse cuts in the solution process for nonconvex QCQPs, analyze how to appropriately select sparse linear relaxations depending on the instance, and present results of preliminary experiments illustrating the precise tradeoffs between sparsity and strength.

3 - Sufficient Conditions for Exact SDP Reformulations of Quadratic Programs

Alex L. Wang, Graduate Student, Carnegie Mellon University, Pittsburgh, PA, United States, alw1@andrew.cmu.edu, Fatma Kilinc Karzan

Quadratically constrained quadratic programming (QCQP) is a fundamental problem that is well-known to be NP-hard in general. In this talk we review and extend known sufficient conditions under which the standard semidefinite programming (SDP) relaxation of QCQP is tight. In particular, we analyze two new conditions depending on the multiplicity of the eigenvalues in the quadratic forms. We additionally give an explicit description of the convex hull of the QCQP epigraph in the original space under similar conditions.

4 - Integer Programming Through Lexicography

Yiran Zhu, Clemson University, Clemson, SC, United States, yiran@g.clemson.edu

In this work, we propose new polyhedral methods for a pure integer program (IP) over a compact set which may not be polyhedral or even convex. Our polyhedral relaxations are based on ordering the lattice points under some monomial order on integer vectors. Furthermore, for a binary program, we establish a new converging hierarchy for the integral hull of the feasible region being of packing or covering type.

■ TB35

CC- Room 604

OPT Integer/Uncertainty: Integer Programming under Uncertainty

Sponsored: Optimization/Integer and Discrete Optimization

Sponsored Session

Chair: Amy Burton, Clemson University, Townville, SC, 29689, United States

1 - A Strong Branch-and-Cut Framework for Robust Integer Programming with Budget Uncertainty Sets

Timo Gersing, RWTH Aachen University, Pontdriesch, Germany, gersing@math2.rwth-aachen.de, Arie Koster, Christina Büsing

Since their introduction by Bertsimas and Sim in the early 2000s, budget uncertainty sets have received a lot of attention in the literature. This is not least due to the existence of a compact robust reformulation for linear programs. Despite its compactness, the reformulation performs poorly when solving robust integer problems due to its weak LP relaxation. We propose a Branch-and-Cut framework that addresses this problem by strengthening the LP relaxation with each branching. Our computational results show that the approach outperforms the sole use of the reformulation by far.

2 - A Mean-risk Stochastic Mixed-integer Program for Network Protection

Amy Burton, Clemson University, Townville, SC, 29689, United States, aburto2@g.clemson.edu, Akshay Gupte

Two-stage stochastic programs are often used to model network resource allocation when there is uncertainty in future performance. We propose a mean-risk mixed integer nonlinear program for network protection that hedges against future extreme events. The model is implemented with coherent risk measures on a transportation network in which the first stage minimizes total retrofitting cost and the second minimizes expected future travel cost. We use perspective relaxations and conic quadratic constraints to derive a convex reformulation of the nonlinear, non-separable second stage. Benders Decomposition is used to solve the model and computational results are presented.

3 - Airline Schedule Planning Using Risk-Averse Two-Stage Stochastic Programming Approach

Saravanan Venkatachalam, Wayne State University, Detroit, MI, 48377, United States, Sujeevraja Sanjeevi

Fleet assignment model (FAM) assigns an aircraft to scheduled flights considering demand, cost, revenue and other operational constraints. We propose a mean-risk two-stage stochastic programming approach under demand uncertainty for FAM. The mean-risk models pose computational challenges. In this talk, we present column generation based decomposition algorithms and computational results.

4 - Optimal Crashing of an Activity Network with Disruptions

Haoxiang Yang, Northwestern University, Evanston, IL, 60208, United States, haoxiangyang2019@u.northwestern.edu

We introduce a general type of sequential decision problem under uncertainty, where the uncertainty consists of a small number of disruptions, both the magnitude and the timing of which can be random. We consider a special case: a project crashing problem under a single disruption. When a disruption occurs, the duration of an activity which has not started could change. The magnitude of the activity duration change and the timing of the disruption can be random. We formulate a stochastic mixed integer programming (SMIP) model with second stage a mixed integer program. We propose a learning-based branch-and-bound algorithm and evaluate the computational performance of our approach.

■ TB36

CC- Room 605

Recent Advances in Planning and Scheduling under Uncertainty

Sponsored: Optimization/Optimization Under Uncertainty

Sponsored Session

Chair: Karmel Shehadeh, MI, United States

1 - Joint Job Sequencing and Due-date Determination with Limited Distributional Information

Yuli Zhang, Beijing Institute of Technology, Beijing, China, zhangyuli@bit.edu.cn, Lun Ran, Zuo-Jun Max Shen

Uncertainty is an inevitable element in manufacturing systems and has a significant impact on the system performance. Recently distributionally robust optimization (DRO) has been recognized as an effective approach to minimize the adverse impact of uncertainty. This paper studies the joint job sequencing and due-date determination problem with limited distributional information. We derive a closed-form expression for the DRO model and show the optimality of the smallest-variance-first rule under special cost structures. We further provide an equivalent mixed 0-1 quadratic conic programming reformulation and design efficient algorithms for problems with general cost structures.

2 - Scenario Generation and Cutting Planes for Stochastic Integer Programming, with Applications to Air Traffic Management

Alexandre Jacquillat, Carnegie Mellon University, Pittsburgh, PA, 15213, United States, ajacquil@andrew.cmu.edu, Kai Wang

We formulate a two-stage stochastic integer program to jointly optimize flight scheduling (at the strategic level) and ground holding operations (at the tactical level) in airport networks. We develop a cutting plane algorithm based on new optimality cuts obtained from the dual relaxation of the second-stage problem, and a neighborhood search to trade off exploration and exploitation. We also propose a data-driven scenario generation approach for stochastic programming. The solution approach provides optimal, or near-optimal solutions in reasonable computational times, and outperforms baseline approaches based on existing algorithms and heuristic scenario generation procedures.

3 - Appointment Systems under Service Level Constraints

Zhenzhen Yan, Assistant Professor (PhD), Nanyang Technological University, School of Physical and Mathematical Sciences, Singapore, Singapore, yanzz@ntu.edu.sg

We consider a new model of appointment scheduling where customers are given the earliest possible appointment times under the service level constraint that the expected waiting time of each individual customer or the probability of long waiting cannot exceed a certain threshold. We apply the theory of majorization to analytically characterize the structure of the optimal appointment schedule. We show the monotonicity of the optimal inter-appointment times and study the limiting behaviour of the appointment system. We also extend our analysis to systems with multiple servers.

4 - A Distributionally Robust Optimization Approach for Outpatient Colonoscopy Scheduling

Karmel S. Shehadeh, University of Michigan, Ann Arbor, MI, 48109, United States, Amy Cohn, Ruiwei Jiang

We present a distributionally robust (DR) optimization approach for colonoscopy scheduling under the coexisting uncertainties of pre-procedure bowel preparation (prep) quality and the procedure duration. Using historical colonoscopy appointment data of a large outpatient procedure center, we infer structural relations between procedure duration and prep adequacy. Accordingly, we propose a new DR sequencing and scheduling model that incorporate these two uncertainties using limited distributional information. From extensive case studies based on real data, we derive interesting managerial insights of colonoscopy scheduling.

■ TB37

CC- Room 606

Sampling-based Methods for Stochastic Programming

Sponsored: Optimization/Optimization Under Uncertainty

Sponsored Session

Chair: Harsha Gangammanavar, Southern Methodist University, Dallas, TX, 75275, United States

Co-Chair: Halit Uster, Southern Methodist University, Dallas, TX, 75275-0123, United States

1 - Prescriptive Scenario Reduction for Stochastic Optimization

Nishanth Mundru, Massachusetts Institute of Technology, Cambridge, MA, United States, Dimitris Bertsimas

We consider stochastic optimization problems when the sample average approximation approach is computationally expensive. We introduce a novel measure, called the Prescriptive divergence which takes into account the decision quality of the scenarios, and consider scenario reduction in this context. We demonstrate the power of this optimization-based approach on various examples.

2 - Parametric Scenario Optimization under Limited Data: A Distributionally Robust Optimization View

Fengpei Li, Columbia University, New York, NY, 10027, United States, fl2412@columbia.edu, Henry Lam

We discuss how to leverage parametric information and the power of Monte Carlo simulation to obtain and certify feasible solutions for chance-constrained optimization problems under limited data. Our approach makes use of distributionally robust optimization (DRO) that translates the data size requirement in scenario optimization into a Monte Carlo size requirement drawn from what we call a generating distribution. We show that, while the optimal choice of this generating distribution is in a sense the one eliciting the data or the baseline in a distance-based DRO, it is not necessarily so in the parametric case, and leads us to some procedures that improve upon these basic choices.

3 - An Adaptive Sequential Sample Average Approximation Framework for Solving Two-stage Stochastic Programs

Yongjia Song, Clemson University, Clemson, SC, 29634, United States, yongjis@clemson.edu, Raghu Pasupathy

In this talk, we present a new adaptive sequential sampling approach for solving two-stage stochastic programs. The adaptive sequential sampling procedure solves the SAA problem of a certain sample size up to an adaptively chosen precision in each iteration, depending on the sampling error corresponding to the candidate solution. Stopping criteria developed in the literature of sequential sampling for stochastic programs are applied to construct asymptotically valid confidence intervals on candidate solutions with high probability. Numerical results on an extensive set of instances on two-stage stochastic linear programs with fixed recourse will be reported.

4 - Adaptive Cluster Sampling-based Approximation for Two-stage Stochastic Programs

Siavash Tabrizian, Southern Methodist University, Dallas, TX, 75206, United States, stabrizian@smu.edu, Harsha Gangammanavar, Halit Uster

We present an adaptive clustering based sampling technique for two-stage stochastic programs, and we discuss its performance for estimating the recourse function. We also present a decomposition algorithm design for solving two-stage stochastic programs and demonstrate its efficiency through numerical experiments on classical test instances.

■ TB38

CC- Room 607

Chance Constrained Programming and its Applications

Sponsored: Optimization/Optimization Under Uncertainty

Sponsored Session

Chair: Jianqiang Cheng, University of Arizona, Tucson, AZ, 85721, United States

1 - Distributionally Robust Chance Constrained Set Covering with a Wasserstein Ambiguity Set

Haoming Shen, University of Michigan, Ann Arbor, MI, United States, Ruiwei Jiang

We consider distributionally robust chance constrained set covering problem with a Wasserstein ambiguity set, in which decision variables and uncertainties are both binary-valued. We derive exact reformulations of the chance constraints. In addition, we derive valid inequalities for the resulting mixed-integer feasible region. Experiments based on randomly generated test instances show the effectiveness of our reformulation and the strength of the valid inequalities.

2 - Chance Constrained Programming in Power Systems: Limited Controllability & Model Uncertainties

Kenneth Bruninx, KU Leuven, Belgium, kenneth.bruninx@kuleuven.be

We discuss two specific applications of chance constrained programming in power system models. First, we study the impact of the limited controllability of demand response resources on an aggregator's interaction with its consumers and the wholesale electricity market. Second, we discuss how modeling inaccuracies (e.g., the approximation of nonlinear pump/turbine performance curves) and model uncertainties (e.g., due to limited knowledge the underground cavity's geometry and hydraulic properties) can be included in the scheduling problem of a underground pumped hydro energy storage system.

3 - A Mixed-integer Distributionally Robust Chance-constrained Model for Optimal Topology Control in Power Grids with Uncertain Renewables

Payman Dehghanian, Assistant Professor, George Washington University, Washington, DC, 20052, United States, payman@gwu.edu, Mostafa Nazemi

We propose a distributionally robust chance-constrained (DRCC) optimization model for optimal topology control in power grids overwhelmed with significant renewable uncertainties. A distributionally robust optimization (DRO) formulation is proposed to guarantee the robustness of the network topology control plans against all uncertainty distributions defined within the moment-based ambiguity set. The DRCC problem is reformulated into a tractable mixed-integer second-order cone programming problem (MISOCP) which can be efficiently solved. Numerical results on the IEEE 118-bus test system verify the effectiveness of the proposed methodology under uncertainties.

4 - A Framework for Solving Chance-constrained Linear Matrix Inequality Programs

Roya Karimi, University of Arizona, Tucson, AZ, 85719, United States, royakarimi1993@email.arizona.edu, Jianqiang Cheng, Miguel Lejeune

In this talk, we present a partial sample average approximation (PSAA) framework to solve chance-constrained linear matrix inequality (CCLMI) problems with random technology matrix and with random right-hand side. We also present computationally tractable PSAA-based approximations, analyze their properties, and derive sufficient conditions ensuring convexity. We derive several semidefinite programming PSAA-reformulations efficiently solved by off-the-shelf solvers and design a sequential convex approximation method for the PSAA formulations. To demonstrate the superiority of this framework, we carry out a comprehensive numerical study on three practical CCLMI problems.

■ TB39

CC- Room 608

Joint Session RAS/Practice Curated: Crew Management in Railway

Sponsored: Railway Applications

Sponsored Session

Chair: Seyed Mohammad Nourbakhsh, BNSF Railway, University of Illinios-Urbana, Fort Worth, TX, 61820, United States

1 - Robust Tactical Crew Scheduling under Fluctuating Demand

Christian Raehlmann, University of Cologne, Albertus-Magnus-Platz, Cologne, 50931, Germany, Felix Wagener, Ulrich Thonemann

We investigate a freight railway crew scheduling problem under fluctuating demand in which the start and end times of duties must be determined four weeks before operations. We seek to find a recoverable-robust schedule that is capable to absorb the structural changes induced by significant changes in train-demand such that the guaranteed on- and off-times of the train drivers are not violated. We decompose the problem twice using a column generation approach. We test our model on several real data sets and show that significantly less stand-by-duties are necessary in order to meet the adjusted demand compared to the nominal crew scheduling problem.

2 - A Heuristic-based Tactical Crew Sizing Model for Freight Railroad

Kiran Chahar, Sr. Manager, Norfolk Southern Corporation, Atlanta, GA, 30309, United States, Kiran.Chahar3@nscorp.com, Clark Cheng

Norfolk Southern (NS) has developed a crew planning tool to optimize the sizes of crew boards while maintaining an on-time train performance. While determining the optimal board sizes, the model simulates federal government regulations and complex crew call rules such as crew rotation, crew tie-up, rest hours, mark-off, carded or assigned jobs, show-up jobs, detention, deadheading, extraboard, and re-crew. The model runs weekly to monitor the crew pool and extraboard sizes. In addition, the model allows what-if analysis using different train plans to ensure that the right number of crews are in place to operate trains.

3 - Scheduling and Routing Roaming Conductors to Support Single-person Crew Operations on North American Freight Railways

Tyler Dick, U. of Illinois at Urbana-Champaign, Urbana, IL, 61801, United States

This research investigates the feasibility of reducing freight train crew sizes by assigning train work events to roaming conductors. Various heuristic routing and scheduling approaches are developed to minimize the number of roaming conductors while assigning them to work events. Results suggest that under different performance standards, operating conditions and practical assumptions, the total number of roaming conductors may be less than the number of on-board conductors required for two-person crews. Under these conditions, roaming conductors can facilitate a net decrease in operating personnel, while still performing all required work events for mainline freight trains.

4 - Railway Crew Rescheduling with Flexible Start and End Times

Felix Wagener, University of Cologne, Cologne, Germany, Ulrich Thonemann

In freight railway crew scheduling employees mostly do not know their work schedule more than a week in advance. This paper presents a model that allows the company to announce a rough schedule, with start and end times that lie within predefined time windows, some weeks in advance by slightly increasing operating cost. We present a trade-off that allows the company to decide either to decrease total cost or to increase the stability for the train drivers. The trade-off helps to find a solutios that create better work conditions for train drivers.

5 - Strategic Passenger Railway Timetabling

Gert-Jaap Polinder, Erasmus University-Rotterdam, Rotterdam, Netherlands

This paper proposes a method to develop strategic timetables, which can help decide on future line plans. This is done by integrating passenger flows with timetabling. Computational results of real life studies are presented.

■ TB40

CC- Room 609

Supply Chain, Competition, and Retail Management

Contributed Session

Chair: Xinyi Ren, University of Maryland, College Park, MD, 20742, United States

1 - Effects of Manufacturer-to-Consumer Rebates in Competitive Environments

Qin Wang, School of Information Management,Central China Normal University, WuHan, China, 13387561952@163.com, Pengyu Chen

In four competitive supply chains, we examine effects of manufacture-to-consumer rebates on prices and production quantities decisions, considering strategic inventories. We find that M-to-C rebates and strategic inventories can benefit manufacturers, retailers, and consumers alike in competitive environment with low holding cost. We also analyze how optimal solutions are influenced by the intensity of competition or complementarity.

2 - Sharing Commitment and Capacity Allocation under Supply Competition

Hongyan Xu, Chongqing University, Chongqing, China, xuhongyan@cqu.edu.cn, He Huang, Xiaomin Liu

We analyze the implication of demand information sharing in a supply chain with one manufacturer sourcing from two capacity-constrained suppliers. Two suppliers compete for both the manufacturer's order and a mature market share. Two rules are examined for the manufacturer to allocate its order, fixed allocation rule and proportional allocation rule. Our results show that under the proportional allocation rule, the manufacturer may have the incentive to share demand information with both suppliers, but always has no incentive to share information under fixed allocation rule.

3 - Buyer's Strategic Demand Information Disclosure to an Upstream Echelon under Entry Threat

Kenji Matsui, Kobe University, Kobe, Japan, kmatsui@b.kobe-u.ac.jp

This paper investigates the information sharing problem of whether a buyer purchasing products from a supplier should disclose its demand information. Contrary to a conventional insight in the literature, the present paper demonstrates that the buyer can increase its own profit by fully disclosing information when there exists not only an incumbent supplier currently operating, but also a potential alternative supplier. This result provides the practical implication that a buyer in a supply chain can strategically reveal demand information, which is seemingly disadvantageous to the buyer, to improve its profit through encouraging entry of another supplier as an alternative source of products.

4 - Retailers' Return Policy Strategies under Competition

Ozgun Caliskan Demirag, Penn State Erie, The Behrend College, Erie, PA, United States, ozc1@psu.edu, Delong Jin, Frank Y. Chen, Min Huang

We investigate retailers' strategic decisions on the adoption of buy-online, return-to-physical store (BORP) policy from a competitive perspective. We find that the adoption of the BORP policy by one or both retailers can be sustained in equilibrium if the retailers are sufficiently differentiated and when they can recover significantly larger salvage values from items returned in-store than those returned online. We fully characterize the equilibrium outcomes and explore several model extensions.

5 - Order Fulfillment Policies for Ship-from-Store Implementation in Omni Channel Retailing

Armagan Bayram, University of Michigan Dearborn, Dearborn, MI, United States, Bahriye Cesaret

We consider an omni-channel retailer having both online and store operations and implementing ship-from-store fulfillment model. We investigate dynamic fulfillment decisions in ship-from-store implementation, specifically from which location to fulfill an online order. We incorporate the uncertainty both in demand and in the cost of shipment to individual customers. We develop a stochastic dynamic programming framework and present some analytical and numerical findings on optimal fulfillment strategies.

6 - The Effect of Pop-up Stores on Customer Retention & Acquisition: Evidence from a Quasi-field Experiment

Xinyi Ren, PhD Candidate, University of Maryland, College Park, MD, United States, xinyi.ren@rhsmith.umd.edu, Philip Evers, Robert Windle

With the increasingly uncertain future of brick-and-mortar retailing, companies are exploring new ways to avoid the high costs associated with traditional full-service stores. One solution, pop-up stores remain a relatively new form of offline retailing. Using industry data collected from a leading North American retailer between 2014 and 2017, we empirically study the impact of opening a pop-up store on sales across multiple channels during and after the opening of a pop-up store. Also, we compare this effect to the opening of a traditional, full-service store by the same retailer.

■ TB41

CC- Room 610

Conic Optimization in Energy

Contributed Session

Chair: Richard Weinhold, Berlin Institute of Technology, Berlin, 10623, Germany

1 - Convex Inner Approximation of Feeder Hosting Capacity Limits on Dispatchable Demand

Nawaf Nazir, Graduate Research Assistant, University of Vermont, Burlington, VT, United States, mnazir@uvm.edu, Mads Almassalkhi

This paper presents a method to obtain a convex inner approximation that aims to improve the feasibility of optimal power flow (OPF) models in distribution feeders. Inaccuracy in linearized OPF models may lead to under and over voltages when dispatching flexible demand, at scale, in response to whole-sale market or grid conditions. In order to guarantee feasibility, this paper obtains an inner convex set in which the dispatchable resources can operate, based on their real and reactive power capabilities, that guarantees network voltages to be feasible. Test simulations are conducted on standard IEEE distribution test networks to validate the approach.

2 - Data-Driven Security Constrained Optimal Power Flow

Spyros Chatzivasileiadis, Technical University of Denmark, Kgs. Lyngby, Denmark, spchatz@elektro.dtu.dk, Andreas Venzke, Lejla Halilbasic, Florian Thams

Current electricity market clearing uses linear approximations of security constraints that are either too conservative or inaccurate, leading to costly redispatching actions . We unify security considerations with electricity market operations. Using data-driven techniques, we extract an accurate representation of the non-convex security region, and incorporate it as conditional linear constraints in an optimization problem. We capture both static and dynamic stability constraints, while being less conservative. Our approach is scalable can eliminate costs of millions of euros every year.

3 - A Cluster-based Approach to Synchronize Electricity Load Profiles in Buildings

Seyyed Danial Nazemi, PhD Student, Rutgers University, Piscataway, NJ, United States, danial.nazemi@rutgers.edu

In this study, a novel cluster-based approach is proposed to synchronize aggregate load profile of a building based on different control actions of end-uses. In this regard, using wavelet transform, a Multi-Resolution Clustering (MRC) algorithm is applied to load profiles to make clustering more accurate. By applying X-means clustering to the spectral components, ans also using our proposed Multi-Objective Optimization (MOO) model based on the results of clustering, the optimal load profiles for each end-use can be found, and then, the smoothest possible aggregate load profile for a building is calculated.

4 - Reduction of Transmission-Grid Constraints for Computationally Efficient N-1 Secure Optimal Power Flow

Richard Weinhold, TU Berlin, Berlin, Germany, riw@wip.tu-berlin.de, Robert Mieth

Power flows and thus electricity market outcomes are constrained by physical transmission system constraints and its security requirements such as the N-1 criterion.Internalization of this criterion in optimal power flow (OPF) analyses often leads to prohibitive computational complexity even for linearized (DC) power flow equations.We present a methodology to obtain a minimal set of linear constraints that yields an exact N-1 secure DC-OPF solution that can be leveraged in multi-period economic analyses. The reduction process depends only on time invariant parameters and needs to be performed only once.The effectiveness of the method is shown on a large-scale real world power system.

■ TB42

CC- Room 611

Graph Algorithms and Applications I

Sponsored: Optimization/Network Optimization

Sponsored Session

Chair: Golshan Madraki, PhD., Clarkson University, Potsdam, NY, United States

1 - Interdicting Layered Physical and Information Flow Networks

N. Orkun Baycik, Shenandoah University, School of Business, Winchester, VA, 22601, United States, Thomas Sharkey, Chase Rainwater

We study the interdiction of layered networks that involve a physical flow and an information flow network. There exist dependencies between these networks since components of the physical flow network are operational should their counterparts in the information flow network receive enough demand. This leads to a network interdiction problem over these layered networks. For the case where the information supply arcs are uncapacitated, we apply a novel multi-step, dual-based reformulation technique. We apply this technique to the application of combating illegal drug trafficking and cyber-physical system security.

2 - Max-min Diversity Problem with Non-identical Facilities

Saeed Chavoshi, North Carolina State University, Dept of Industrial Engineering, Raleigh, NC, 27695-7906, United States, schavos@ncsu.edu, Yahya Fathi

We consider the max-min diversity problem in which there is a weight associated with each facility and we wish to locate a collection of p facilities on a given set of n nodes (n larger than or equal to p) so as to maximize the minimum weighted pairwise distance among the located facilities. We propose an iterative algorithm for solving this problem and propose effective methods for solving the corresponding IP model at each iteration. We also present the results of a limited computational experiment.

3 - Block-structure Based Time-series Models for Graph Sequences

Mehrnaz Amjadi, UIC, Chicago, IL, United States, Theja Tulabandhula

Although the computational and statistical trade-off for modeling single graphs, for instance, using block models is relatively well understood, extending such results to sequences of graphs has proven to be difficult. In this work, we take a step in this direction by proposing two models for graph sequences that capture: (a) link persistence between nodes across time, and (b) community persistence of each node across time. For both of these proposed models, we provide statistically and computationally efficient inference algorithms, whose unique feature is that they leverage community detection methods that work on single graphs.

4 - Learning Steady-States of Iterative Algorithms Over Graphs

Le Song, Georgia Institute of Technology, Atlanta, GA, 30332, United States, Hanjun Dai

Many graph problems can be solved via iterative algorithms where the solutions are often characterized by a set of steady-state conditions. Different algorithms respect to different set of fixed point constraints, so instead of using these traditional algorithms, can we learn an algorithm which can obtain the same steady-state solutions automatically from examples, in an effective and scalable way? How to represent the meta learner for such algorithm and how to carry out the learning? We propose an embedding representation for iterative algorithms over graphs, and design a learning method which alternates between updating the embeddings and projecting them onto the steady state constraints.

5 - Interdicting Interdependent Contraband Smuggling, Money and Money Laundering Networks with Uncertain Information

Yeming Shen, Rensselaer Polytechnic Institute, Troy, NY, United States, sheny15@rpi.edu, Thomas Sharkey, Boleslaw Szymanski, William A. Wallace

This paper focuses on the problem of interdicting the interdependent contraband smuggling, money and money laundering (ICSML) networks of a transnational criminal organization (TCO). There are four interdependencies among these networks: money flows from the contraband smuggling network to the money network, support from the money network flows to the smuggling network, money flows from the money network to the laundering network and incentives from the laundering network flow to the smuggling and money networks. Our computational analysis focuses on the impact of inaccurate or incomplete information about the TCO on our interdiction decisions.

■ TB43

CC- Room 612

Data-driven Decision Making and Decision Diagrams

Sponsored: Computing

Sponsored Session

Chair: Amin Hosseininasab, Carnegie Mellon University, Pittsburgh, PA, 15217, United States

1 - Integrating Decision Diagrams into Generative Adversarial Networks for Data-driven Decision-making

Willem-Jan Van Hoeve, Carnegie Mellon University, Tepper School of Business, 5000 Forbes Avenue, Pittsburgh, PA, 15213, United States, vanhoeve@andrew.cmu.edu, Yexiang Xue

Many decision-making problems aim to maximize (implicit) user preferences for which no algebraic or rule-based description exists. This makes it challenging to directly apply classical optimization technologies such as integer programming or constraint programming. An alternative is to generate solutions from a neural network that represents the preferences, but these solutions often fail to satisfy operational constraints. We present a hybrid approach, DDGAN, that embeds Decision Diagrams into Generative Adversarial Networks. It filters the solutions generated from the neural network through a decision diagram to ensure feasibility. We evaluate DDGAN on routing/scheduling problems.

2 - Reward Potentials for Learned Neural Networks

Buser Say, University of Toronto, Toronto, ON, M6K 0B4, Canada, bsay@mie.utoronto.ca, Scott Sanner, Sylvie Thiébaux

Optimal planning with learned neural networks (NNs) in continuous action/state spaces is a challenging task for branch-and-bound solvers due to the poor linear relaxation of the underlying mixed-integer linear programming (MILP) model. For a given set of features, potential heuristics provide an efficient framework for computing bounds on reward functions. We model the problem of finding an optimal potential heuristic for learned NNs as a bilevel program, and solve it with constraint generation. We then strengthen the linear relaxation of the MILP model by valid constraints to bound the reward function based on the precomputed potentials, and show results on efficiency and runtime improvements.

3 - Decision Diagrams for Real-Time Routing Applications

Ryan J. O’Neil, nextmv, Philadelphia, PA, United States, ryan@nextmv.io, Karla L. Hoffman

Decision Diagrams are a rapidly developing optimization technology with many attractive qualities for real-time routing in industry. These include fast discovery of high quality solutions, inherent testability and interpretability, and low communication overhead for parallelization. We examine the use of Decision Diagrams for meal delivery and ride sharing, present computational results, and give some recommendations regarding their implementation.

4 - Structure Mining for Interpretable Data-driven Sequential Decision Making

Amin Hosseininasab, Carnegie Mellon University, Pittsburgh, PA, 15217, United States, aminh@andrew.cmu.edu, Willem-Jan Van Hoeve, Andre Augusto Cire

Learning algorithms are generally evaluated by prediction accuracy, which has entailed the development of complex highly nonlinear models. Unfortunately, the complexity of such predictors is a barrier to their adaption in many decision making problems. This has led to increasing interest in interpretable algorithms for management science applications, albeit with lower accuracy. In this talk, we present a systematic approach towards generating interpretable but also accurate knowledge for sequential decision making problems. We show the benefits of our approach using an example in marketing, where we investigate methods to reduce the skip rate of users in online music streaming platforms.

■ TB44

CC- Room 613

Joint Session ICS/DM: Optimization in Machine Learning II

Sponsored: Computing

Sponsored Session

Chair: John W Chinneck, Carleton University, Ottawa, ON, K1S 5B6, Canada

1 - Approximating L1-Norm Best-Fit Lines

J. Paul Brooks, Virginia Commonwealth University, School of Business, Richmond, VA, 23284, United States, jpbrooks@vcu.edu, Jose Dula

Fitting subspaces is a fundamental task in data analysis techniques such as linear regression and principal component analysis and for applications including ranking and recommendation. L1-norm best-fit subspaces provide benefits including outlier insensitivity, but can be difficult to compute. We derive sufficient conditions for L1-norm line fitting and in doing so reveal the algorithm with the best-known approximation factor having the lowest computational complexity.

2 - Mixed-integer Conic Programming for Learning Directed Acyclic Graphs from Continuous Data

Hasan Manzour, University of Washington, Seattle, WA, 98195, United States, hmanzour@uw.edu, Simge Kucukyavuz, Ali Shojaie

We study sparse directed acyclic graph (DAG) learning of a Bayesian network from continuous observational data. This problem is commonly modeled using a standard big-M constraint in the associated mixed-integer program. However, this strategy leads to poor continuous relaxations because there is no natural upper bound for the arc weights. To circumvent this deficiency, we reformulate the problem as a mixed-integer second-order cone program (MISOCP), which entails tighter continuous relaxation compared to the existing formulations based on big-M constraints. Our numerical results demonstrate that the MISOCP clearly outperforms the existing big-M formulations.

3 - Solving Map Estimation via Mixed-integer Quadratic Optimization and Customized Branch-and-bound

Pitchaya Wiratchotisatian, Worcester Polytechnic Institute, Worcester, MA, 01609, United States, pwiratchotisatia@wpi.edu, Patrick Flaherty, Andrew C. Trapp

We study maximum a-posteriori (MAP) estimation for the Gaussian mixture model. This problem features challenging nonconvex and non-separable components in which existing approaches often sacrifice global optimality for quick convergence. We formulate MAP as a mixed-integer quadratic program using piecewise linear approximation. Even so, this NP-hard problem may require significant running time to find a global optimum. We develop custom branch and bound methods that accelerate convergence to global optimality, and compare the efficiency and quality of solutions with standard MAP methods.

4 - On the Cluster-wise Supervised Learning: A New Framework and Globally Convergent Algorithm

Weijun Xie, Virginia Tech, Department of Industrial and Systems Engineer, Blacksburg, VA, 24061, United States, Shutong Chen

In supervised learning, there might be hidden structures in the dataset, which require unsupervised learning techniques to improve the results. Therefore, this paper integrates the clustering with supervised learning, to simultaneously find the best clusters of the data points and minimize the empirical loss function within each cluster. We develop a novel regularized alternating projection method with global convergence. Our numerical study demonstrates both the efficiency and effectiveness of the proposed method compared to the existing ones (e.g., random forests).

■ TB45

CC- Room 614

Large Scale Semidefinite Programming

Sponsored: Optimization/Nonlinear Programming

Sponsored Session

Chair: Madeleine Udell

Co-Chair: Lijun Ding

1 - Sublinear Time Linear Algebra for Structured Matrices

David P. Woodruff, PhD. in Computer Science, Carnegie Mellon University, Pittsburgh, PA, 15213, United States

There are a number of approximation algorithms for NP-hard versions of low rank approximation, such as finding a rank-k matrix B minimizing the sum of absolute values of differences to a given matrix A. These error measures are special cases of the following general entrywise low rank approximation problem: given an arbitrary function g, find a rank-k matrix B which minimizes the entrywise g-function loss. A natural question is which functions g admit efficient approximation algorithms. We give approximation algorithms for every function g which is approximately monotone and satisfies an approximate triangle inequality, and we show both of these conditions are necessary.

2 - Convex Optimization for Overlapping Community Detection

Jimit Majmudar, University of Waterloo, Waterloo, ON, Canada, jmajmuda@uwaterloo.ca, Stephen Vavasis

In the community detection problem, the goal is to recover communities in a graph. “Communities” are defined as cliques or dense subgraphs, and we may assume that the graph is generated according to some specified generative model. This problem is well-studied in the situation in which the communities do not overlap. For the case of overlapping communities, Arora et al. (2011) provide a combinatorial approach and Anandkumar et al. (2014) provide a tensor factorization approach for recovery. In this work, we provide the first convex optimization approach for recovering overlapping communities. Our method is also robust to reasonable noise in the input graph.

3 - An Optimal-storage Approach to Semidefinite Programming Using Approximate Complementarity

Lijun Ding, Cornell University, Ithaca, NY, 14850, United States

This talk develops a new storage-optimal algorithm that provably solves generic semidefinite programs (SDPs) in standard form. This method is effective for weakly constrained SDPs. The key idea is to formulate an approximate complementarity principle: Given an approximate solution to the dual SDP, the primal SDP has an approximate solution whose range is contained in the eigenspace with small eigenvalues of the dual slack matrix. This result suggests an algorithmic strategy that can be implemented with minimal storage: (1) Solve the dual SDP approximately; (2) compress the primal SDP to the eigenspace with small eigenvalues of the dual slack matrix; (3) solve the compressed primal SDP.

4 - Bundle-type Methods for Dual Atomic Pursuit

Zhenan Fan, The University of British Columbia, Vancouver, BC, Canada, zhenanf@cs.ubc.ca

The aim of structured optimization is to assemble a solution, using a given set of (possibly uncountably infinite) atoms, to fit a model to data. A two-stage algorithm based on gauge duality and bundle-type methods is proposed. The first stage discovers the optimal atomic support for the primal problem by solving a sequence of approximations of the dual problem using a bundle- type method. The second stage recovers the approximate primal solution using the atoms discovered in the first stage. The overall approach leads to implementable and efficient algorithms for large problems.

■ TB46

CC- Room 615

Parking Behavior and Management

Sponsored: Transportation Science & Logistics/Intelligent Transportation Systems (ITS)

Sponsored Session

Chair: Xinlian Yu, University of Massachusetts-Amherst, Amherst, MA, 01003, United States

1 - Location of Parking Facilities in the Era of Autonomous Vehicles

Mahmood Tarighati Tabesh, Graduate Research Assistant, Purdue University, West Lafayette, IN, United States, mtarigha@purdue.edu, Mohammad Miralinaghi, Samuel Labi

Drivers in metropolitan downtown areas continue to face challenges in finding parking locations. In an era of Autonomous Vehicles (AVs), it is expected that travelers can directly travel to their destination and dispatch their AVs to park at distant locations. For a mixed fleet (AV and human-driven vehicles) environment that will characterize the AV transition period, this study presents a general framework for locating parking facilities. We formulate the problem as a mixed-integer nonlinear problem and use the well-known Bender's decomposition method to solve it. The findings can help transportation planners to address parking issues associated with the AV transition period.

2 - Puzzle-based Parking

Parag Siddique, University of Louisville, Louisville, KY, United States, parag.siddique@louisville.edu, Kevin Gue

The potential for remote control of autonomous cars suggests new ways to increase parking density for urban settings. We describe a general model for very high density parking based on the popular sliding block puzzle Rush Hour. Our designs suggest improvements of 70-80% are possible.

3 - Operation of Shared Autonomous Vehicle Systems: Optimal Fleet Sizing and Depot Deployment

Xinlian Yu, University of Massachusetts-Amherst, Amherst, MA, 01003, United States, Alireza Khani

Autonomous vehicles (AVs) can relocate themselves automatically to any traveler's location upon request, and thus potentially improve the efficiency of vehicle sharing system, as they can relocate themselves automatically to any traveler's location upon request. This study aims to develop a systematic approach for planning and operating a fleet of shared AVs by addressing a number of practical challenges: the fleet sizing, depot deployment and capacity, as well as routing and relocating algorithms.

4 - The Morning Commute of Traditional Vehicles with Considering a Parking Space at Network Level

Reza Ansari Esfe, University of Calgary, Calgary, AB, Canada, Lina Kattan

The morning commute problem has been studied with different assumptions in a single bottleneck. At the first time, the morning commute problem was discussed by Vickery (1969) to investigate the trip of people having identical behavior preferences in the morning with a single and fixed capacity bottleneck. Then, it is discussed by considering homogenous and heterogeneous preferences, with one parking and multiple parking zones or without parking space and with an autonomous or traditional vehicle. However, modeling the network level is much more realistic. In this study, we talk about the user equilibrium in the network level by considering parking space constraint near the workplace. We use Speed-MFD to model the congestion and consider the traditional vehicle. To define the morning commute in this study, a number of commuters travel through the downtown network and reach their destination. The desired arrival time is identical for all commuters. There parking spaces near commuter's destination with infinite capacity Np. In addition, we assume the real-time speed of each commuter, which is changing by the variation of the commuters' number in the network, that is in contrast with the studies considering a fixed speed, departing speed or arrival speed, therefore; this assumption helps us to make a more realistic model.

■ TB47

CC- Room 616

TSL Special Invited Speaker Session

Sponsored: Transportation Science & Logistics

Sponsored Session

Chair: Alan Erera, Georgia Institute of Technology, Atlanta, GA, 30332-0205, United States

1 - TSL Distinguished Lecture: 2019 Robert Herman Lifetime Achievement Award Winner

To Be Announced, Lifetime Achievement, Award, AL, United States

This talk will be given by the 2019 awardee of the TSL Robert Herman Lifetime Achievement Award, and the award winner will be revealed at the Monday TSL Business Meeting. The Robert Herman Lifetime Achievement Award in Transportation Science is awarded by the INFORMS Transportation Science and Logistics Society to an individual who throughout his or her professional career has made fundamental and sustained contributions to transportation science and logistics, and has influenced the field through her or his writings, teaching, service, and nurturing of younger professionals.

■ TB48

CC- Room 617

Joint Session TSL/Frt/Practice Curated: Physical Internet and Distribution Networks

Sponsored: Transportation Science & Logistics/Freight Transportation & Logistics

Sponsored Session

Chair: Shahab Derhami, Georgia Tech-ISYE, Atlanta, GA, 30332, United States

1 - Assortment Planning in Interconnected Retail Networks

Shahab Derhami, Georgia Tech, 755 Ferst Drive, NW, Atlanta, GA, 30332, United States

In this talk, we propose a mixed integer programming model to solve the assortment planning problem in an interconnected network of retailers distributing high-value substitutable products such as cars and recreational vehicles, where retail centers exploit on-demand inventory transshipment to satisfy the demand for out-of-stock products. The model finds the optimal assortment to maximize the total profit under uncertain demand, customer substitution, long order-to-delivery lead time, and obsolescence cost.

2 - Assessing Time-Sensitive Availability of Substitutable Products Across Downstream Supply Chains and Retail Networks

Benoit Montreuil, Georgia Institute of Technology, Industrial & Systems Engineering, Atlanta, GA, 30332-0205, United States, Shahab Derhami

We introduce a product availability performance indicator measuring the current capability of a retail center to meet demand from customers for each of the products in its offer portfolio. It accounts for customer time-based service expectations, product demand share estimates, product substitution, product transfers from other retailers in the network as well as other supply chain sources. We demonstrate using Product Availability Ratio (PAR) for a large North American network of high-value products, highlighting key insights and impacts.

3 - Showcasing Optimization in Omnichannel Retailing

Iman Dayarian, University of Alabama, Tuscaloosa, AL, 35487, United States, idayarian@cba.ua.edu, Ji Soo Park, Benoit Montreuil

We focus on a setting in which customers prefer to visit an offline showroom to experience the products in person to gain sufficient confidence in their potential purchase. An order is placed next and the product is delivered to the customer. We propose a quantitative approach to optimize the showcasing value for a retailer to maximize the exposure of the features that customers expect to experience from a visit to a showroom. The numerical results of a case study on data obtained from dealerships of our industrial partner show that the showcasing value for a retailer can significantly increase, even in the presence of spatial and/or budget constraints.

4 - Providing Menus of Choices for Crowdsourced Suppliers in Open Platform Systems

Jennifer Pazour, Rensselaer Polytechnic Institute, Troy, NY, 12180-3522, United States, pazouj@rpi.edu, Hannah Horner, John E. Mitchell

Open platform systems, in which decentralized suppliers provide access to their resources to fulfill demand requests, are becoming common in distribution and logistics. We propose and evaluate a new hierarchical approach to coordinate decentralized resources by recasting the platform's role as one providing personalized menus of requests for decentralized suppliers to choose from.

■ TB49

CC- Room 618

Shared Mobility Systems: Optimization

Sponsored: Transportation Science & Logistics/Urban Transportation

Sponsored Session

Chair: Hai Wang, Singapore Management University, Singapore, 178902, Singapore

1 - High-capacity Ride-pooling with Electric Vehicles

Matthew Zalesak, Cornell University, Ithaca, NY, United States, mdz32@cornell.edu, Samitha Samaranayake

We study the effects of using electric vehicles in online ride-pooling systems. Prior work has shown that online algorithms perform well for high capacity ride-pooling systems. We propose an mixed integer linear program to extend these algorithms to the electric vehicles setting, with the primary objective of maximizing the number of requests satisfactorily served. Then we show a faster, scalable algorithm with similar performance that is practical for large-scale systems. Our contributions show the importance of having knowledge and estimates of future demand even when operating in the online setting.

2 - Estimating Primary Demand in Bike-sharing Systems

Chiwei Yan, Uber Technologies, San Francisco, CA, United States, University of Washington, Seattle, WA, United States, Chong Yang Goh, Patrick Jaillet

We consider the problem of estimating the primary or first-choice demand for a bike-sharing service using trip and inventory data. To account for choice substitutions, we propose a rank-based demand model that treats each observed trip as the best available option in a latent ranking over origin-destination pairs. We then solve a high dimensional estimation problem using algorithms that (i) find sparse representations of the parameters efficiently, and (ii) constrain trip substitutions spatially according to the bike-share network. Our method is effective in recovering the primary demand and computationally tractable on a city scale, as we demonstrate on a bike-sharing service in Boston.

3 - Relocation Optimization for Empty Vehicles on Shared Transportation Platforms

Hai Wang, Singapore Management University, School of Information Systems, Singapore Management University, Singapore, 178902, Singapore, Carnegie Mellon University, Pittsburgh, PA, United States, Zhengli Wang

Due to stochastic demand, supply, and their imbalance on shared transportation platforms, the relocation guidance for empty vehicles (idle drivers) is very important to improve passenger service level, driver income, and platform revenues. In this paper, we study the empty vehicles relocation guidance problem using a two-stage model. First, we propose a general idealised relocation policy and its theoretical guarantee assuming that all travel times between regions are equal within a time unit; second, we study the specific relocation optimization considering practical general travel times among regions and provide performance bounds both theoretically and numerically.

4 - Reservation vs. On-demand Ride-hailing Platforms

Ziwei Cao, University of Maryland, College Park, MD, 20740, United States, Michael O. Ball

We consider a market where a dominant firm provides an Uber-like on-demand service and a startup provides reservation service. Customer valuations are differentiated based on preference for the service offered by different platforms. We study how the reservation platform makes pricing, wage and expansion decisions under competition.

■ TB50

CC- Room 619

Economics and Transportation Operations

Contributed Session

Chair: Muge Tekin, Universitat Pompeu Fabra, Ramon Trias Fargas, 27, UPF, Barcelona, 08005, Spain

1 - The Impact of Bolsa Familia on Unhealthy Behaviors

Fernanda Araujo Maciel, PhD Candidate, Bentley University, Waltham, MA, United States, fmaciel@bentley.edu

The objective of this paper is to assess the impact of Brazil's Bolsa Familia conditional cash-transfer program on unhealthy behaviors, which is measured by expenses with ultra-processed foods, alcohol, and smoking products. Applying Machine Learning methods to improve Propensity Score Matching, I analyze the intensive margin, extensive margin, and overall effect. Results show that program participants increase the expenditure of food, food away from home, and cookies. Among households that purchase soda or smoking products, the amount spent on these products reduces.

2 - Attitudes Toward Risk and Cost Pass-through under Uncertainty

Phat Luong, Rutgers University, Newark, NJ, United States, Xiaowei Xu

This paper takes into account the difference in risk-aversion of producers to explain the degree of cost pass-through. Each producer can be either risk-neutral or risk-averse, characterized by a CARA utility function. We find that the maximal pass-through differentiation structure arises if one supplier is risk-neutral (e.g., a Chinese state-owned enterprise) but the other is risk-averse (e.g., a domestic private enterprise). Contrarily, if both suppliers are similarly risk-averse (e.g., American vs. European producers), then the pass-through rates stay in the range of 40%-60% at market equilibrium. We also find that tariff is inefficient to promote the competitiveness of domestic producer.

3 - Mathematical Model for Ridesharing Matching Algorithm Optimization

Luiza Marques Fonseca dos Santos, Texas Tech University, Lubbock, TX, United States, luiza.santos@ttu.edu, Jia Li

Isolation in rural areas creates the Last Mile problem. Ridesharing systems can fill this gap, but it relies on the matching mechanism for its efficiency. This paper tries to identify the matching algorithms which ensure the consistency of the ridesharing systems. We propose that ridesharing stability is related to the size of the market. We expand optimization models found in the literature by introducing the characters of drivers and passengers relating to maximum waiting time and spatial distribution.

4 - Characterizations for DTA Modelling under User Equilibrium Conditions and Convergence of Solutions for Some Stochastic DTA Cases

Ricardo de la Paz Guala, PhD Student, Universidad de Chile, Santiago, Chile, delapaz8866@gmail.com, Cristian Eduardo Cortes, Pablo Andres Rey

When studying the factors that affect traffic, analyzing how demand is assigned (Traffic Assignment) among routes is fundamental. Currently, the Dynamic Traffic Assignment (DTA) problem, which faces the time dependency of route choice under conditions as User Equilibrium (UE) and, particularly, the Stochastic DTA (SDTA) problem, which integrates uncertainty on route choice, have become determinant tools for this type of analysis. We present characterizations of fundamental functions that fully define DTA for some general cases and prove that, for some of this cases, the solution of SDTA, with a logit route choice model, converges to the solution of its equivalent DTA.

5 - Facility Location Decisions from Public Data

Muge Tekin, Imperial College Business School, London, United Kingdom, m.tekin@imperial.ac.uk, Kalyan Talluri

Econometric analysis is challenging for the restaurant industry since it includes taste, quality and value that are unobservable. To tackle the challenges, we make use of social media, demographic and geographic data to infer an operational decision: the optimal location and design for a restaurant considering the long term benefits.

■ TB51

CC- Room 620

Joint Session AAS/TSL Air/Practice Curated: Airline Scheduling

Sponsored: Aviation Applications

Sponsored Session

Chair: Bruno F. Santos, TU Delft, Delft, 2629 HS, Netherlands

1 - Integrated Flight Scheduling and Fleet Assignment with Improved Supply-demand Interaction Modeling

Sebastian Birolini, PhD Student, Department of Management, Information and Production Engineering, University of Bergamo, Dalmine (BG), Italy, sebastian.birolini@unibg.it, António Pais Antunes, Mattia Cattaneo, Paolo Malighetti, Stefano Paleari

This paper presents an alternative approach to deal with supply-demand interactions in flight scheduling and fleet assignment optimization models. Different from demand correction terms, the proposed approach simultaneously solves the demand generation and allocation problems allowing for flexible itinerary-utility specifications. Computational testing reveals that the model can handle mid-size hub-and-spoke networks to optimality in reasonable time. The benefits that can be derived from the application of the approach are illustrated for a major European airline.

2 - Dynamic Evaluation of Airline Crew Flight Requests

Bruno F. Santos, Assistant Professor, TU Delft, Faculty of Aerospace Engineering, Delft, 2629 HS, Netherlands, b.f.santos@tudelft.nl, Lennart Scherp, Maud Beulen

In airline crew rostering, crew members' requests to operate specific flights need to be evaluated efficiently to avoid inefficient schedules. This is a dynamic problem, in which requests are submitted while others have already been granted and pre-assigned. We propose a neural-network algorithm to evaluate flight requests, providing a systemic way of assessing flight requests. To train and test this algorithm, we developed an innovative rolling rostering framework that solves a linear programming crew rostering method in multiple time periods with the help of a column-generation algorithm. The framework is tested in a case study with a major European airline.

3 - A Strategic Multistage Tactical Two-stage Stochastic Optimization Model for the Airline Fleet Management Problem

Luis Cadarso, Rey Juan Carlos University, Camino del Molino s/n, Fuenlabrada, 28943, Spain, luis.cadarso@urjc.es, Adrian Serrano, Javier Faulin

This work proposes stochastic optimization for the airline fleet management problem, considering uncertainty in the demand, operational costs, and fares. In particular, a multistage tree is proposed, compounded of strategic and tactical nodes. At the former ones, fleet composition decisions are made, while at the latter ones, aircraft assignment decisions are formulated. Computational experiments are based on a network with seven strategic nodes and fourteen tactical nodes (i.e., seasons) where two fleet types are available. The results provide the optimal fleet mix and assignment at both strategic and tactical scopes.

4 - Reducing Crew Split in Multi-rank Pairing Optimization Problems

Yogesh Dashora, Sabre Corp., Southlake, TX, United States, yogesh.dashora@sabre.com, Olof Damberg, Tomas Karlsson

Airlines having multi base operations across various countries have always been troubled with the problem of keeping their crew together for the entire length of trip while still maintaining the manpower limitations and costs minimal. Although there are various restrictions that can be placed in the optimization system to try to achieve these goals, recently we have tried techniques for reducing the number of different bases, number of different pairing types, or number of pairings covering a set of flight legs within our optimization framework. We intend to provide overview of the mathematical complexity while keeping the business aspect of the problem in the highlight.

5 - An Innovative and Efficient Solution Methodology to Integrated Fleet Assignment Problem

Shahram Shahinpour, Sabre Inc., Fort Worth, TX, 76155, United States, Sergey Shebalov Shebalov, Peter Sun

Fleet assignment deals with assigning an equipment type to a flight to best match seat capacity with passenger demand in order to maximize profit. Fleet assignment models (FAM) that consider origin and destination effect and integrate other aspects of demand forecasting systems have been proven to be very hard to solve. In this talk we explore the root cause for the intractability of such problems and propose a solution methodology to origin and destination fleet assignment and extensions to integrated FAM. Numerical experiments with real datasets from airlines show significant benefits of the proposed method.

■ TB52

CC- Skagit 1

Data-driven Decision-making in Pricing and Ordering

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Boxiao (Beryl) Chen, University of Illinois at Chicago

1 - Online Learning Algorithms for Multi-product Inventory Systems with Point of Sales Data

Xiangyu Gao, The Chinese University of Hong Kong, RM909 Cheng Yu Tung Building, Shatin, Hong Kong, Hong Kong, Huanan Zhang

We consider a periodic-review multi-product inventory system where each consumer's demand is affected by the product availabilities. In this model, the total sales are affected by the arrival sequence and preferences of consumers. When the full distributional information of the demand is not available, the decision-maker has to learn the information on-the-fly, through the partial and censored feedback of customers. We introduce a UCB-based algorithm to balance the learning and earning tradeoff. Due to the high-dimensionality of the policy space, we propose two methods to improve the efficiency of our algorithm.

2 - Data-driven Approximation Schemes for Joint Pricing and Inventory Control Models

Hanzhang Qin, Massachusetts Institute of Technology, Cambridge, MA, 02142, United States, hqin@mit.edu, David Simchi-Levi, Li Wang

We study the classic multi-period joint pricing and inventory control problem in a data-driven setting. We propose a data-driven approximation algorithm, which uses the past demand data to solve the joint pricing and inventory control problem. We assume the retailer does not know the noise distributions or the true demand functions; instead she only has access to demand hypothesis sets that contain the true demand functions. We prove the algorithm's sample complexity bound, the number of data samples needed to guarantee a near-optimal profit. A simulation study suggests that the data-driven algorithm solves the dynamic program effectively.

3 - Tailored Base-Surge Policies in Dual-Sourcing Inventory Systems with Demand Learning

Boxiao (Beryl) Chen, University of Illinois-Chicago, Chicago, IL, 60607, United States, bbchen@uic.edu, Cong Shi

We consider a periodic-review dual-sourcing inventory system, in which the expedited supplier is faster and more costly, while the regular supplier is slower and cheaper. Under full demand distributional information, it is well-known that the optimal policy is extremely complex but the celebrated Tailored Base-Surge (TBS) policy performs near optimally. In this paper, we assume that the firm does not know the demand distribution a priori, and makes adaptive inventory ordering decisions in each period based only on the past sales data. We develop the first nonparametric learning algorithm that admits the best possible convergence rate.

4 - Discontinuous Demand Functions: Estimation and Pricing

N. Bora Keskin, Duke University, Fuqua School of Business, Durham, NC, 27708-0120, United States, bora.keskin@duke.edu, Arnoud Victor den Boer

In random utility models, customer utility distributions exhibit point masses in the presence of income effects, transportation costs, and network effects. These point masses naturally result in discontinuities in the expected demand as a function of price. Motivated by this, we consider a dynamic pricing-and-estimation problem with an unknown and discontinuous demand function. We show that ignoring such discontinuities results in substantial loss of revenues, and construct near-optimal policies that can handle demand discontinuities.

■ TB53

CC- Skagit 2

Learning in Strategic Environments

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Santiago Balseiro, Columbia University, New York, NY, 10027, United States

Co-Chair: Daniel Russo, Columbia University, New York, NY, 60208, United States

1 - Learning and Earning in Competitive Environments

John R. Birge, University of Chicago, Chicago, IL, 60637, United States, John.Birge@ChicagoBooth.edu

Competition can dramatically change decisions regarding exploration and learning. This talk will discuss conditions for such incomplete learning.

2 - Bid Prediction in Repeated Auctions with Learning Agents

Vasilis Syrgkanis, Microsoft Research, Cambridge, MA, 02142, United States, vasy@microsoft.com

We consider the problem of bid prediction in repeated auctions from past bidding data. We formulate two models of learning behavior, one based on mean field asymptotics and one based on no-regret learning. We propose an econometric approach to estimation of the structural parameters of both the type of the player and the learning algorithm. We subsequently solve the bid prediction problem by forward simulation. We evaluate our approach on a real-world data set from sponsored search auctions in Bing. We find that bid prediction based on gradient descent style behavioral assumptions outperforms most machine learning approaches that treat the problem as a pure time series problem.

3 - On the Futility of Dynamics in Robust Mechanism Design

Anthony Kim, Columbia University, New York, NY, United States, aek2185@columbia.edu, Santiago Balseiro, Daniel Russo

We consider a broad class of problems in which a principal repeatedly interacts with a strategic agent over a finite discrete-time horizon. In each round, the agent privately observes idiosyncratic shocks drawn independently and identically from a distribution known to him but not to the principal. When the principal commits to a dynamic mechanism, the agent best-responds to maximize his aggregate utility over the rounds. We show the minimax regret is linear in the time horizon and repeatedly implementing a single-round mechanism is optimal without any meaningful dynamics. Outside the class of problems, we construct an example in which a dynamic mechanism can provably outperform static mechanisms.

4 - No Regret Learning on Games with Imperfect Information

Zhengyuan Zhou, Stanford University, Stanford, CA, 94305, United States

We discuss some of the recent results in learning on games, where each player employs a no-regret learning algorithm to update its action in an unknown, time-varying environment that consists of other agents who are simultaneously engaged in a similar online decision making process.

■ TB54

CC- Skagit 3

Online Advertising and Digital Marketplace Platforms

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Sami Najafi

1 - Distributionally Robust Convex Regression

Zhengqing Zhou, Stanford University, Stanford, CA, United States, Jose Blanchet, Peter W. Glynn

Convex regression recognizes non-linearities that are often a part of problem settings in which linear regression is used mostly because of tractability considerations. This work presents a natural distributionally robust optimization formulation for convex regression analysis which has many advantages relative to standard formulations. First, the underlying convex function is easier to fit than in standard least-square algorithms. Second, it is more robust, not only by design but also in terms of empirical performance. Statistical rates of convergence guarantees are also supplied, which are not-worst than those obtained in current estimators.

2 - Customer Choice Models Versus Machine Learning: Finding Optimal Product Displays on Alibaba

Jacob Feldman, Olin Business School, Saint Louis, MO, 63108-1291, United States, jbfeldman@wustl.edu, Dennis Zhang

We compare the performance of two approaches for finding the optimal set of products to display to customers landing on Alibaba's two online marketplaces, Tmall and Taobao. Both approaches were placed online simultaneously and tested on real customers for one week. The first approach we test is Alibaba's current practice. This procedure embeds thousands of product and customer features within a sophisticated machine learning algorithm that is used to estimate the purchase probabilities of each product for the customer at hand. Our second approach uses a featurized multinomial logit (MNL) model to predict purchase probabilities for each arriving customer.

3 - Managing Digital Advertising Campaigns

Sami Najafi Asadolahi, Santa Clara University, Leavey School of Business, Santa Clara, CA, 95053, United States, snajafi@scu.edu, Naren Agrawal, Stephen A. Smith

Advertising agencies manage numerous ad campaigns for multiple clients in real-time. Because of uncertainties in the demand from campaigns for viewers, and the rate at which the target viewers visit websites, ensuring that campaigns proceed according to plan is a difficult challenge. We describe a methodology to manage such campaigns.

4 - Extended Sampled Trees for Classification and Regression

Omar Skali, Massachusetts Institute of Technology, Cambridge, MA, United States, oskali@mit.edu, Georgia Perakis, Divya Singhvi

Our objective is to develop a Machine Learning model for classification and regression that is interpretable, scalable, suitable for a learning framework and that is competitive in terms of accuracy. In particular, we propose an Extended Sampled Trees (XSTrees) algorithm, which extends linearly the splits of individual tree-based methods such as CART, then introduces a Bayesian distribution over this tree space. We prove probabilistic guarantees, and benchmark it against state-of-the-art methods on synthetic data, publicly-available datasets, and a real-world case study.

■ TB55

CC- Skagit 4

Revenue Management in Online Marketplaces

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Negin Golrezaei, Google Inc., Google Inc., Cambridge, MA, 02142, United States

Co-Chair: Vahideh Manshadi, Yale University, New Haven, CT, 06511, United States

1 - Product Ranking on Online Platforms

Negin Golrezaei, MIT, Massachusetts Institute of Technology, Cambridge, MA, 02142, United States, golrezae@mit.edu, Mahsa Derakhshan, Vahideh Manshadi, Vahab Mirrokni

On online platforms, consumers face an abundance of options that are displayed in the form of a ranking. Only products placed in the first few positions are readily accessible to the consumer, and she needs to exert effort to access more options. For such platforms, we develop a two-stage search model, wherein the first stage, the consumer sequentially screens positions to learn the preference weight of some products and forms a consideration set. In the second stage, she learns the additional idiosyncratic utility of the products in her consideration set. For this model, we characterize the optimal search policy of consumers. We then study how platforms with objectives should rank products.

2 - Matchings in Ride Sharing Platforms: A Two Stage Robust Optimization Approach

Oussama Hanguir, Columbia University, New York, NY, 10025, United States, oh2204@columbia.edu, Omar El Housni, Vineet Goyal, Clifford Stein

We consider the problem of matching riders to drivers in ride sharing platforms where such matchings need to be made in the presence of uncertainty for both agents. We consider a two-stage robust optimization approach to model the problem where we decide on the matching between the given agents in the first stage before observing the second-stage (adversarially chosen) scenario of agents. The goal is to select a first-stage matching such that the worst-case total cost is minimized. We show that this problem is NP-hard even with two scenarios. We consider myopic and threshold policies to approximate the problem and show that a myopic policy gives a good approximation for the case of metric distances.

3 - Surge Pricing and its Spatial Supply Response

Francisco Castro, Columbia University, Columbia School of Business, New York, NY, 10027, United States, Omar Besbes, Ilan Lobel

We study the pricing problem faced by a ride-hailing platform. We propose a two-dimensional framework in which a platform selects prices for different locations, and drivers respond by choosing where to relocate in equilibrium based on prices, travel costs and driver congestion. The general structure of an optimal pricing policy creates a menu of locations. In some, prices are set so that supply and demand are matched; over-congestion is induced in others, and some less profitable ones are indirectly priced out. We also study a family of models characterized by a demand shock. In this case, the platform will use prices to balance supply and demand around the shock, but also to induce movement away from it.

4 - Ridesharing and the Use of Public Transportation

Katherine Hoffman Pham, NYU Stern School of Business, New York, NY, United States, khoffmann@stern.nyu.edu, Panos Ipeirotis, Arun Sundararajan

We investigate the relationship between on-demand ridesharing via platforms like Uber/Lyft and the use of public transit systems. Our study uses trip count data on ridesharing, taxi, shared bike, and subway usage in New York City. Exploiting a series of exogenous shocks to the system (the closing of subway stations) to isolate substitution effects, we find that the average shock is associated with a 2.8-3.3% increase in the use of ridesharing. This shows that on-demand ridesharing acts as infrastructure that helps smooth unexpected supply and demand surges, but the effect is small relative to the estimated average number of subway rides displaced per zone and four-hour period.

■ TB56

CC- Skagit 5

Logistics Models for Disaster Response and Public Health Emergencies

Sponsored: Public Sector OR

Sponsored Session

Chair: Ashlea Millburn

1 - A Data-driven Optimization Approach for Multi-period Location-specific Resource Allocation in Cholera Outbreak

Nan Kong, Purdue University, Biomedical Engineering, West Lafayette, IN, 47906-2032, United States, nkong@purdue.edu, Mu Du, Aditya Sai

We consider a multi-period location-specific intervention resource allocation problem of cholera outbreak with missing local disease state information. We propose a data-driven optimization approach to determine the optimal intervention strategy in a rolling-horizon manner, which can make decisions with progressively incoming observations. We integrate model parameter fitting and scenario-based stochastic programming at each period. We conduct comparative studies to assess the performance of our approach and offer insights into intervention policy development.

2 - Locating Emergency Shelters in Consideration of Spatial and Aspatial Elements of Accessibility

Ashlea Bennett Milburn, University of Arkansas, 4207 Bell Engineering Center, Fayetteville, AR, 72701, United States, ashlea.bennett@uark.edu, Justin Taylor

Disaster response shelters should be located so as to maximize their accessibility by impacted populations who need them. A variety of spatial and aspatial factors influence shelter accessibility, such as the relationship between supply and demand in an area, and the levels of mobility and health care needs of people living in an area. This research creates a shelter accessibility metric inclusive of these components and formulates a linear program for locating shelters to maximize this new measure. The metric and optimization model are demonstrated for a case study based on Hurricane Florence.

3 - What Explains State Variations in the Number of Deaths from Opioid Overdose?

Negar Darabi, PhD Student, Virginia Tech, Blacksburg, VA, United States, darabi@vt.edu, Niyousha Hosseinichimeh

The number of deaths from opioid overdoses has increased dramatically over the last 16 years in the United States. Because of the severity of the opioid epidemic in the year 2017, this issue was announced as the “National Emergency”. We constructed a state-level panel data for 50 states of the U.S. plus the District of Columbia from 2008 to 2017 and we used a fixed effect regression model to explore the association between death from opioid overdose and a number of explanatory variables across different states. Our independent variables include insurance type, unemployment rate, income level, education level, and state policies on opioid prescription.

■ TB57

CC- Yakima 1

Pro Bono Analytics - Providing Analytics Support to Nonprofit Organizations

Sponsored: Public Sector OR

Sponsored Session

Chair: David T Hunt, Oliver Wyman, Princeton, NJ, 08540, United States

Moderator

David T. Hunt, Oliver Wyman, Princeton, NJ, 08540, United States

Pro Bono Analytics (PBA) is an INFORMS program to match analytics professionals willing to volunteer their skills with nonprofit organizations that would benefit from analytical techniques. This panel session will include Seattle area nonprofit representatives and PBA volunteers discussing the unique challenges of introducing analytics solutions into nonprofit organizations. The nonprofit representatives will discuss their organization and analytical needs, while the PBA volunteers will discuss their experience working with the nonprofit. Time will be allowed for an audience discussion.

Panelists

- Louis Luangkesorn, University of Pittsburgh, Pittsburgh, PA, United States
- Rachel Chung, Chatham University, Pittsburgh, PA, United States
- Elise Tinseth, FareStart, Seattle, WA, United States

■ TB58

CC- Yakima 2

Data-Driven Insights for Decision-Making

Sponsored: Public Sector OR

Sponsored Session

Chair: Hongcheng Liu

1 - Computational Evaluation of New Mixed Integer Programming Models for Tree Ensembles Optimization

Bijan Taslimi, University of Florida, Gainesville, FL, 32603, United States, b.taslimi@ufl.edu, Jean-Philippe P. Richard, Jongeun Kim, Mohit Tawarmalani

Tree ensemble models are widely used to predict the value of a dependent variable as a function of independent variables. When the independent variables are controllable, the value of the dependent variable can be optimized by adjusting the values of the independent variables. Mixed Integer Programming models have recently been proposed for such tree ensembles optimization problems. In this presentation, we consider new MIP formulations for this problem and compare their computational characteristics. We also present heuristic algorithms that can obtain near-optimal solutions efficiently.

2 - Training Prediction Models for Two-stage Linear Programs with Uncertain Right-hand Sides

Alexander Stewart Estes, University of Minnesota, 2929 University Ave SE, Apartment 606, Minneapolis, MN, 55414, United States, este0100@umn.edu, Jean-Philippe P. Richard

Consider a two-stage linear programming problem where the right-hand side of the second stage is unknown, and we are interested in fitting a regression model to predict these unknown quantities. Oftentimes, the prediction model is trained to minimize a standard loss function, such as mean square error, that is not directly related to the objective function of the optimization problem. We instead provide a convex loss function that is aligned with the objective function, and we demonstrate how to train models using this loss function.

3 - A Two-stage Optimization Algorithm to Learn Parameters of a Kernel Smoother

Sam Davanloo Tajbakhsh, The Ohio State University, 210 Baker Systems Building, 1971 Neil Ave, Columbus, OH, 43210, United States, sam.tajbakhsh@gmail.com, Necdet Serhat Aybat, Enrique Del Castillo

Learning parameters of a kernel smoother requires solving a nonconvex optimization problem. The problem is aggravated in high-dimensional settings for anisotropic kernels where the number of parameters scales with the dimension. In this work, we propose a two-stage optimization algorithm to learn kernel parameters. First, a convex likelihood-based problem regularized with a weighted l_1 norm is solved to get a sparse inverse covariance matrix. Second, the kernel parameters are estimated by solving a least-square problem. Theoretical error bounds for the proposed estimator are provided. Some numerical studies supporting the proposed algorithm will be provided.

■ TB58a

CC- Chelan 1

10:30-11:15 SAS / 11:15-12:00 Frontline Systems, Inc.

Vendor Tutorial

1 - Building and Solving Optimization Models with SAS

Ed Hughes, SAS, Northants, United Kingdom, Rob Pratt

SAS provides a broad and deep array of data and analytic capabilities, including data integration, statistics, data and text mining, econometrics and forecasting, and operations research. The SAS optimization, simulation, and scheduling features coordinate easily and fully with other SAS strengths in data handling, analytics, and reporting.

OPTMODEL from SAS provides a powerful and intuitive algebraic optimization modeling language and unified support for building and solving LP, MILP, QP, NLP, CLP, and network-oriented models. And because the OPTMODEL optimization modeling language is contained within the OPTMODEL procedure, a SAS software module, it integrates seamlessly with the entire family of SAS functions, procedures, and macros. We'll demonstrate how you can use OPTMODEL to solve both basic and advanced problems, highlighting its newer capabilities and its support for both standard and customized solution strategies.

2 - Using Analytic Solver® Cloud for Teaching

Daniel H. Fylstra, Frontline Systems, Inc., Incline Village, NV, 89450-4288, United States

Introduced in May 2019 and now widely used, Analytic Solver® Cloud solves the biggest problems that faculty members experience when teaching analytics, especially to business students. Excel for Macintosh, Excel for Windows, and Excel Online are all fully supported. Setup is easier than ever: No download or Setup program is needed, and all students are using the same software version at all times. Requirements are just a current Office 365 subscription (free for students from Microsoft) and continuous Internet access. Supporting multiple leading textbooks, with responsive tech support for faculty and students, Analytic Solver Cloud simplifies your life when teaching.

■ TB59

CC- Chelan 2

ENBIS: Modelling and Industrial Statistics, Applications and Issues in SPC, DOE and Reliability

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Antonio Pievatolo

1 - Monitoring of Count Data Time Series: Cumulative Sum Change Detection in Poisson Integer Valued GARCH Models

Arda Vanli, Florida State University, Department of Industrial Eng., Tallahassee, FL, 32310, United States, oavanli@eng.fsu.edu, Rupert Giroux, Eren Erman Ozguven, Joseph J. Pignatiello

In this talk we present a new cumulative sum (CUSUM) monitoring approach for count-data time series. A seasonal integer valued generalized autoregressive conditional heteroscedasticity (INGARCH) time series model with Poisson deviates is used to develop a likelihood ratio test formulation to detect changes in the process accounting for temporal correlations and seasonality. The approach is applied for monitoring traffic crash counts and roadway safety improvement.

2 - Minimal Aliasing Optimal Designs for Non-Linear Models

Anna Errore, Carlson School of Management, University of Minnesota, Minneapolis, MN, United States, aerrore@umn.edu, R. Dennis Cook, Christopher J. Nachtsheim

Foldover designs induce statistical independence between first order linear effects and two-factor interactions in designs for linear models, so that linear main effects estimates are not biased by two-factor interactions effects. We use constrained optimization to explore the construction of designs for non-linear models with the same property. Our primary goal is to maximize the efficiency for a first order logistic regression model, subject to a constraint on the bias induced by the omission of two-factor interactions. To operationalize this optimization, we attempt to construct designs with parameter orthogonality between the parameters associated with the first and second order models.

3 - Applying SPC and DoE Methods in Continuous Processes under Feedback Control

Francesca Capaci, Luleå University of Technology, Lulea, Sweden, francesca.capaci@ltu.se

Standard statistical process control (SPC) and design of experiments (DoE) methods rely on the assumption that processes operate in open-loop. Continuous processes often work under engineering process control as in the case of feedback controllers. Accordingly, SPC and DoE methods need to be adapted when applied in these production environments. This talk explores potential challenges of using SPC and DoE methods in processes under feedback control. Simulated examples using the Tennesse Eastman process simulator under a decentralized feedback control strategy show how an analyst may adapt and use SPC and DoE methods for quality improvement efforts.

4 - Bayesian Virtual Age in Repairable Systems

Didem Egemen, National Cancer Institute - NIH, Alexandria, VA, 22315, United States, Fabrizio Ruggeri, Refik Soyer

Repairable systems are subject to different repair protocols upon each failure of the system. These include minimal, imperfect and perfect repairs. We are proposing a unifying virtual age model, which combines all three repair types and introduce generalizations of the repair models existing in the literature. Virtual age concept differentiates between the operational age and the current condition of the repairable system. The introduced models under the unifying model structure are extended further based on the dependence structure between the repair actions. For statistical inference, a Bayesian framework is considered and Markov Chain Monte Carlo methods are used for inference.

■ TB60

CC- Chelan 4

Machine Learning for Process Monitoring and System Informatics

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Chenang Liu, Blacksburg, VA, 24060, United States

Co-Chair: Chen Kan, University of Texas-Arlington, Euless, TX, 76039-6215, United States

1 - Unsupervised Anomaly Detection in Presence of Embedded Low Dimensional Manifold

Imtiaz Ahmed, Texas A&M University, College Station, TX, 77840, United States, imtiazavi@tamu.edu, Travis Galoppo, Yu Ding

In higher dimensional space, data points are more likely to embed a complicated structure thus leading to a nonlinear manifold. In the presence of such complicated space structure, the direct Euclidean distance between two points does not represent their intrinsic distance anymore. Minimum Spanning Tree (MST), a graph-based measure can help us to approximate these true geodesic distances among points. In this work, we apply MST metric to measure the similarities of neighborhood points and use it as a regularizer to assist the machine learning techniques to obtain proper low dimensional representation in latent space which can in turn be used into detecting anomalies.

2 - Functional Gaussian Directed Graphical Models

Ana M. Estrada, PhD. Student, Georgia Institute of Technology, Atlanta, GA, 30332, United States, ameg3@gatech.edu, Kamran Paynabar, Massimo Pacella

A directed graphical model aims to represent the probabilistic relationship between variables in a system. Several methods have been developed for graphical models with low-dimensional variables. However, the case in which the variables are high-dimensional has not been studied thoroughly. This paper proposes a novel methodology to learn the structure and predict in the functional setting. When the structure of the network is known, function-to-function regression is used to estimate the parameters of the graph. When the goal is to learn the structure, a penalized least square loss is employed. Through simulations and a case study, the advantage of the proposed method is proven.

3 - A Deep Forest-based Supervised Learning Approach for High Dimensional Data Analysis

Chen Kan, University of Texas-Arlington, Arlington, TX, 76039-6215, United States, chen.kan@uta.edu, Chenang Liu, Jihoon Chung

High-dimensional data provide a great opportunity for process monitoring but pose significant challenges in modeling and analysis. Recently, deep learning (DL) is increasingly used to handle these data and extract pertinent information about process dynamics. However, most DL models, including CNN, contain too many hyperparameters and the performance is highly dependent on parameter tuning, which is very time consuming and may lead to suboptimal results. To address this problem, this study introduces and improves a deep forest approach for the analysis of high-dimensional data. Experimental results show the proposed approach is more robust compared with widely used DL models.

4 - Nonparametric Change-point Detection with Parsimonious Smoothing for Real-time Process Monitoring

Shenghan Guo, Rutgers University, Piscataway, NJ, 08854, United States, sg888@scarletmail.rutgers.edu, Weihong (Grace) Guo

Machine faults and systematic failures are revealed by pattern changes in manufacturing data. Early recognition of such changes can preclude issues that cause severe profit loss. Change-point detection identifies the time when abnormal patterns occur, thus ideal for pattern recognition in manufacturing processes. In this paper, we develop an innovative change-point detection method based on Parsimonious Smoothing. An effective and efficient criterion is proposed for change-point selection, whose explicit upper/lower bound is given by a solid theoretical framework.

5 - Bootstrap Distributionally Robust Optimization

Xue Wang, Pennsylvania State University, University Park, PA, 16802, United States, wxie91@gmail.com, Changcheng Li, Tao Yao, Runze Li

A board class of machine learning problems involves optimizing an expectation which the exact underlying distribution is unknown. One popular approach to address the distributional uncertainty, distributionally robust optimization (DRO), is to optimize the problem with respect to the worst distribution in the uncertainty set. The key ingredient of DRO is the uncertainty set construction. The inappropriate uncertainty set can lead to an unnecessary conservative solution. In this paper, we propose a novel DRO framework, Bootstrap DRO (BDRO), in which we applied the bootstrap technique. In addition, we design the computation algorithm solves the BDRO problem.

■ TB61

CC- Chelan 5

Design for Quality Excellence in Additive Manufacturing

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Sungku Kang

Co-Chair: Ran Jin, Virginia Tech, Blacksburg, VA, 24061, United States

1 - Data Driven Fatigue Modeling of Additive Manufactured Parts by Establishing Process Property Relationship

Linkan Bian, Mississippi State University, Industrial and Systems Engineering Department,Mississippi State University, MS, 39762, United States, bian@ise.msstate.edu, Seyyed Selfi, Wenmeng Tian, Aref Yadollahi, Haley Doude

One major barrier for broader adoption of additive manufacturing is inferior fatigue properties of the final products, caused by the presence of internal defects. We propose a data-driven methodology to predict the size and location of porosities based on in-situ process signatures, i.e. thermal history. Size as well as location of pores highly affect the resulted fatigue life where near-surface and large pores, compared to inner or small pores, significantly reduces the fatigue life. The model proposed is validated using a thin wall fabricated by a direct laser deposition process and the multistage fatigue (MSF) modelsimulations.

2 - Designed Experiments on Additive Manufacturing Systems for Inference on Interference in Shape Deviations

Arman Sabbaghi, Purdue University, West Lafayette, IN, 47907, United States, sabbaghi@purdue.edu

Additive manufacturing (AM) is a promising manufacturing technique marred by geometric shape deviations. Control of shape deviations in an AM system can be achieved based on statistical deviation models. However, little attention has been paid to performing inference on interference in shape deviations, or incorporating interference in deviation models. We investigate interference with designed experiments on an AM system that involve in-plane deviations for different types of cylinders and different settings of a stereolithography machine. Our work illustrates a principled framework for detecting, inferring, and modeling interference via designed experiments on an AM system.

3 - Feasible Design Region Identification in Additive Manufacturing via Surrogate Modelling of Design Rules

SungKu Kang, Virginia Polytechnic Institute and State University, Blacksburg, VA, 24060, United States, kangsungku@vt.edu, Xinwei Deng, Ran Jin

Additive manufacturing provides great design flexibility for personalized product realization. However, as the flexibility yields complicated design space, it is time-consuming to identify feasible design candidates with conventional simulation-based design exploration. To address the issue, we propose the feasible design region identification method via surrogate modelling of design rules, much more efficient than simulation. We elaborate the method from microbial fuel cell anode design and demonstrate that feasible regions can be quickly identified for efficient design exploration. The method can contribute to timely product realization cycle adapting to mass personalization.

4 - Leveraging Additive Manufacturing Qualification Data During the Design Process

Paul Witherell, National Institute of Standards and Technology (NIST), Gaithersburg, MD, United States

With the maturation of Additive Manufacturing (AM) as a production process, AM parts are increasingly being operationally deployed to meet unique design requirements. However, part designs are being accepted only after strenuous testing and qualification of the material, process, and part for a given design. Each part requires its own acceptance procedures, often including the delivery of large amounts of data to instill a level of quality assurance. This presentation discusses the types of data being generated and curated during the AM process, the analytics opportunities being created, and initial efforts to incorporate this data back into the design decision-making process.

■ TB62

CC- Tahoma 1

Data-driven Approaches to Chronic Diseases

Sponsored: Health Applications

Sponsored Session

Chair: Ilbin Lee

1 - Capturing Natural Progression of Amyotrophic Lateral Sclerosis (ALS) Based on Static and Dynamic Risk Factors

F. Safa Erenay, University of Waterloo, Waterloo, ON, N2N 0A2, Canada, ferenay@uwaterloo.ca, Ozden Onur Dalgic, Haoran Wu, Mustafa Y. Sir, Kalyan Pasupathy, Osman Ozaltin, Brian Crum

We proposed a tollgate-based staging system for capturing natural progression of ALS. Using data from Mayo Clinic-Rochester, we applied classification methods to convert a large ALS dataset from PROACT database into tollgate information. Using the longitudinal data of over 3000 ALS patients, we predicted the timing of key tollgate events (e.g., needing a wheel chair, needing feeding tube, loosing functionality in both arms) and analysed statistically significant static/dynamic factors. We then use a Markov Process based prescriptive model to determine timing of assistive device interventions to maximize quality of life.

2 - Is Separately Modeling Sub-populations Beneficial for Medical Decision-making?

Ilbin Lee, University of Alberta, School of Business, University of Alberta, Edmonton, AB, T6G 2R6, Canada, ilbin@ualberta.ca

In recent applications of Markov decision processes, transition probabilities and rewards are often estimated from large-scale sequential data. In health applications, sequential data are collected from a population where each sequence corresponds to a person. Thus, there may be sub-populations that exhibit heterogeneous transition patterns. In this work, we study the benefit of making optimal decisions separately for different subpopulations and derive a theoretical bound on the benefit. We also suggest a method to estimate the benefit and empirically illustrate it. Lastly, we discuss several intuitions derived from the theoretical and empirical analyses.

3 - Determining the Optimal Timing of Diabetic Retinopathy Screening Exams

Taewoo Lee, University of Houston, Houston, TX, 77204-4008, United States, Poria Dorali

Diabetic retinopathy (DR) is the leading cause of blindness in American adults. While timely treatment can prevent up to 98% of DR-related blindness, only 30-60% of the patients are screened on a yearly basis due to high cost and inconvenience. Teleretinal screening is receiving increasing attention as an affordable and moderately accurate technique, yet little is known how it should be implemented for different patient subgroups to maximize clinical benefits. In this study, we propose discrete even simulation and POMDP approaches to determine the optimal timing of DR teleretinal and in-clinic screening exams using data from a screening program in Harris County.

4 - A Data-driven Framework for Personalizing Patient Encounters for Diabetes Care

Han Ye, U. of Illinois at Urbana-Champaign, Champaign, IL, 61820, United States, hanye@illinois.edu, Ujjal Mukherjee, Dilip Chhajed

We consider a data-driven approach to personalize encounters for diabetes patients. We first use machine learning models to predict future diabetes risks for individual patients, with patient-level clinical, demographic, and encounter data, as well as zip-code level socioeconomic information. We then use the predicted risks as inputs to build a decision model to optimally allocate encounters to individual patients.

5 - Monitoring HIV Treatment under Different Resource Settings

Huaiyang Zhong, Stanford University, Stanford, CA, 94305, United States, hzhong34@stanford.edu, Margaret L. Brandeau

In order to achieve viral load suppression for HIV infected individuals, treatment should be closely monitored to identify the correct time to change treatment regime since drug resistance/treatment failure is detected. Under different resource settings, we need to adapt the monitoring strategy to data and infrastructure we can access. Our work develops an integrated machine learning and partially observed Markov decision process to identify the best treatment monitoring strategy.

■ TB63

CC- Tahoma 2

Healthcare Delivery: Models, Data, and Applications

Sponsored: Health Applications

Sponsored Session

Chair: Mabel Chou, National University of Singapore, Singapore, 118699, Singapore

1 - Optimal Stopping for Medical Treatment with Predictive Information

Zhichao Zheng, Singapore Management University, Lee Kong Chian School of Business, Singapore, 178899, Singapore, danielzheng@smu.edu.sg, Guang Cheng, Jingui Xie

The availability of data and development in machine learning techniques enable accurate prediction of patient future condition. We develop (partially observable) Markov decision process models incorporating (imperfect) predictive information to support medical treatment continuation decisions. We characterize the structure of the optimal policies and show that knowing even moderately accurate predictive information can lead to more personalized policies and significantly improved medical outcomes. We calibrate and test our model for the extubation problem in the intensive care unit using a patient-level dataset of more than 3,000 cases.

2 - On the Design of Customized Colorectal Cancer Screening Policies to Improve Screening Guideline Compliance

Yini Gao, Singapore Management University, Lee Kong Chain School of Business #4031, Singapore, 178899, Singapore, yngao@smu.edu.sg, Zhichao Zheng, Yan He

As one of the leading causes of cancer-related deaths in many countries, nowadays, colorectal cancer is actually curable but the key lies in its early detection and treatment. Undergoing regular screening (pre-tests followed by colonoscopy) can significantly increase the chance of earlier detection and reduce cancer mortality. Despite that fact that the accuracy of colonoscopy is nearly 100%, the compliance rate of taking colonoscopy is far below desired. Our study aims to design more effective and customized initial screening guidelines so that the compliance rate (the probabilities of taking colonoscopy given at least one positive pre-test result) can be improved.

3 - A Robust Approach to Study Multiple Treatments: Hierarchical Contrast-specific Propensity Score

Shasha Han, National University of Singapore, NUS Business School, Singapore, shashahan@u.nus.edu, Joel Goh, Fanwen Meng, Donald Rubin

To prevent or delay the onset of the complications for diabetic patients is challenging, in part because healthcare providers lack treatment guideline at clinic operational level. In this study, we are motivated by this setting, specifically, a provider has to decide among three treatment options: no-medication and two classes of medications (statins and fibrates) to control cholesterol for a newly-diagnosed diabetic patient. We develop a new approach that obtains causal effects of multiple treatments from observational data. We discuss how our approach overcomes several limitations of existing methods; in particular, the approach enjoys robustness to some model misspecifications.

4 - Data Analytics for Hospital Capacity Planning

Mabel C. Chou, National University of Singapore, Singapore, 118699, Singapore

We study a portering system with the goal of improving the porters' performance and the stability of the system. The porters' performance is indicated by their KPI fulfilment rate, while the stability of the system is indicated by the magnitude and occurrences of variability in various response timings. We carry out performance and demand analysis to identify the worst performing day and task time, as well as to seek insights on the stability of the demand. Our results help to identify bottlenecks for the system and provide insights on how to achieve better capacity management in such a system.

5 - Does Ownership Conversion from Nonprofit to For-profit Benefit the Public? Evidence from U.S. Nursing Homes

Susan F. Lu, Purdue University, West Lafayette, IN, 47907, 4-United States, lu428@purdue.edu, Lauren Xiaoyuan Lu

Employing a large panel dataset of U.S. nursing homes from 2006 to 2015, we conduct a difference-in-differences analysis on converted facilities' financial performance, operating policies, and quality of care. We observe that converted facilities significantly increased their post-conversion profit margins, compared to propensity-score-matched controls.

■ TB64

CC- Tahoma 3

OR in Healthcare: Queuing Optimization Models in Healthcare

Sponsored: Health Applications

Sponsored Session

Chair: Janiele Custodio

1 - Response Time Optimization for Drone-Delivered Automated External Defibrillators

Justin J. Boutilier, University of Wisconsin - Madison, Madison, WI, 53706, United States, Timothy Chan

Out-of-hospital cardiac arrest (OHCA) is a time-sensitive medical emergency claiming over 400,000 lives each year and an automated external defibrillator (AED) is one of the only effective methods for treating OHCA. In this paper, we propose an integrated location-queuing model to minimize the total number of drones required to meet an average response time goal while guaranteeing a sufficient number of drones are located at each base. We develop a novel reformulation technique that allows us to solve real-world instances and determine the optimal deployment of AED-enabled drone resources using eight years of data covering 26,000 square kilometers around Toronto, Canada.

2 - Relieving Congestion and Improving Patient Welfare for the Case of Compassionate Dialysis

Farnaz Nourbakhsh, Southern Methodist University, Dallas, TX, 75243, United States, Olga Bountali, Sila Cetinkaya

Modeling the compassionate dialysis process motivated by a real life application at a county hospital, we analyze congestion mitigation policies motivated by alternative routing and prioritization schemes and inspired by queueing theory. Our approach provides policy alternatives informing medical personnel and government decision makers.

3 - Improving Patient Transfer Protocols for Regional Stroke Networks

Beste Kucukyazici, Michigan State University, East Lansing, MI, H3A 1G5, United States, Amir Ardestani Jaafari

We develop an analytical framework to enrich stroke routing decisions that incorporates spatial variation in population density, time and severity of stroke, and congestion levels at the hospitals. We develop predictive models to estimate outcomes associated with given stroke-network and optimize patient allocations under stochastic demand and congestion-dependent service time.

4 - Minimization of the Response Time of Queuing-based Drone Delivery Models with Decision-dependent Uncertainty

Janiele Custodio, Geoge Washington University, Washington, DC, 20011, United States, janiele@gwu.edu, Miguel Lejeune

Drones are emerging technologies with a wide range of applications. One of its potential use is to reduce the delivery time of automated external defibrillators (AEDs) to cardiac arrest occurrences. This research presents second-order cone programming reformulations of queuing-based optimization models for drone network delivery of AEDs. The problem is a stochastic-location allocation model with decision dependent uncertainty. We use queuing theory to model the congestion of the system. We show the equivalent convex reformulation for two cases: discrete facility location and facility location on the plane.

■ TB65

CC- Tahoma 4

Applications of OR & Analytics in Healthcare

Sponsored: Health Applications

Sponsored Session

Chair: Vedat Verter, McGill University, Montreal, QC, H3A 1G5, Canada

1 - Machine Learning for the Opioid Prescription Epidemic

Alireza Boloori, Assistant Professor, Michigan State University, East Lansing, MI, United States, aboloori@asu.edu, Soroush Saghafian, Stephen J. Traub

Opioid epidemic has been largely attributed to the over-prescription of opioid painkillers. As a result, many medical guidelines have recently urged healthcare providers to lessen opioid prescriptions in their medical practices. This, however, could negatively affect those patients who suffer from acute or chronic pain symptoms. Utilizing commercial insurance claims and encounters data, we first analyze the trade-off between the opioid epidemic and pain management. Based on our results, we then provide recommendations for both policymakers and healthcare providers.

2 - Optimization Model for Staff Scheduling

Kimia Ghobadi, Johns Hopkins University, Baltimore, MD, United States, kimia@jhu.edu, Sauleh Ahmad Siddiqui, Scott R. Levin, Eric Hamrock

We consider the scheduling of support staff (e.g., nurses) in healthcare environments. The workload predictors for support staff are frequently different from the providers (e.g., medically stable but distruptive patients increase the workload for nurses but not necessarily for providers). In this work, we consider short-term staffing based on patient census prediction and workload prediction to inform a series of optimization problems. The model finds an optimal staffing assignment that is robust against patient variability and the uncertainty in the prediction simulation.

3 - Managing Telemedicine Platforms with Independent Physicians

Xianyi Wang, Renmin University of China, Beijing, China, 2016102585@ruc.edu.cn, Xiaofang Wang, Frank Y. Chen

In a telemedicine platform, quality of service typically depends on the service rate. Thus, in addition to the quality and speed trade-o , the manager needs to decide the wage paid to physicians who make individual decisions whether or not to join the platform with the help of mobile Internet. In a strategic queueing framework, we study how a telemedicine platform make the optimal service fee, wage and service rate decisions. We show several insights with respect to social welfare and the e ects of regulation policies.

4 - Optimal Ranges for Personalized Treatment Planning

Wesley J. Marrero Colon, University of Michigan, Ann Arbor, MI, United States, wmarrero@umich.edu, Mariel Sofia Lavieri

We present a method to obtain ranges of near-optimal treatment choices based on reinforcement learning and multiple comparisons theory. Reinforcement learning is used to provide a general framework on how to find approximately optimal treatment plans when the standard dynamic programming assumptions are not met. We model the ranges of near-optimal treatment choices as simultaneous confidence intervals on the difference of the approximate value functions using a bootstrap approach. Our methodology is applied for the management of cardiovascular diseases.

5 - Technology Assessment for Blood Pressure Measurement

Vedat Verter, McGill University, Faculty of Mgmt, Montreal, QC, H3A 1G5, Canada, vedat.verter@mcgill.ca, Manaf Zargoush, Mehmet Gumus

Applanation Tonometry (AT) is more accurate than the traditional blood pressure measurement technique. Since it is also more invasive and costly, the value of the provided information is scrutinized by physicians. Employing machine learning, we assess the value of AT from the patients' perspective, based on real life data.

■ TB66

CC- Tahoma 5

Recent Advances in Process Monitoring of Complex Data

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Kai Yang

1 - Process Monitoring of Short-range Serially Correlated Data

Peihua Qiu, University of Florida, Gainesville, FL, 32610, United States, pqiu@ufl.edu

In practice, serial data correlation almost always exists in sequential data. It has been well demonstrated in the literature that control charts designed for independent data are unstable for monitoring serially correlated data. In this talk, we present our recent methodologies for monitoring serially correlated data, which do not impose restrictive assumptions on data correlation and data distribution.

2 - Dissimilarity-Based Variation Identification for Point Cloud Data

Anh Tuan Bui, Virginia Commonwealth University, Technological Institute,Richmond, VA, 60208, United States, Daniel Apley

Point cloud (PC) data from laser scanners provide rich information about the surface geometry of the scanned parts. We develop a method for identifying part-to-part variation using PC data. We propose a novel, computationally efficient dissimilarity measure between PCs based on kd-tree concepts, and use manifold learning on these dissimilarities to discover a low-dimensional parameterization of the part-to-part variation patterns. Visualizing how the parts change as the manifold parameters are varied helps build an understanding of the physical characteristic of each variation pattern. Our approach clearly reveals the nature of the variation patterns in PC data of several examples.

3 - An Effective Method for Online Disease Risk Monitoring

Lu You, University of Florida, Gainesville, FL, 32611, United States, you3939@ufl.edu, Peihua Qiu

Many diseases can be prevented or treated if they are detected early. Disease early detection and prevention (DEDAP) thus has a great impact on health improvement of our society. In this paper, we suggest a novel and effective new method for DEDAP. To detect a disease by this method, a patient's risk to the disease is first quantified at each time point, and then the longitudinal pattern of the risk is monitored sequentially over time. A signal will be triggered by a large cumulative difference between the risk pattern of the patient under monitoring and the risk pattern of a typical person without the disease in concern. Both theoretical arguments and numerical studies show that it works well in practice.

4 - Online Sequential Monitoring of Disease Incidence Rates

Kai Yang, University of Florida, Gainesville, FL, 32611, United States, yklmy1994121@ufl.edu, Peihua Qiu

Online sequential monitoring of disease incidence rates is critically important for public health. For disease surveillance purposes, conventional CUSUM and EWMA charts are usually included in numerous biosurveillance systems. However, these charts require many assumptions about the data structure of the observations. In practice, these assumptions are hardly valid, making the results from the conventional charts unreliable. Motivated by an application to monitor the Florida influenza-like illness data, we develop a new online monitoring approach, which can accommodate the dynamic nature of disease incidence rates, spatio-temporal data correlation, and arbitrary data distribution.

■ TB67

S- Virginia

Simulation and Statistical Learning

Sponsored: Simulation

Sponsored Session

Chair: Zeyu Zheng

1 - Improving the Expected Improvement Algorithm

Chao Qin, Columbia Business School, New York, NY, United States, CQin22@gsb.columbia.edu, Daniel Russo, Diego Klabjan

The expected improvement (EI) algorithm is a popular strategy for information collection in optimization under uncertainty. EI is widely known to be too greedy, but nevertheless enjoys wide use due to its simplicity and ability to handle uncertainty and noise in a coherent decision theoretic framework. To provide rigorous insight into EI, we study its properties in a simple setting of Bayesian optimization. In this framework, one can show formally that EI is far from optimal. To overcome this shortcoming, we introduce a simple modification of EI. Surprisingly, this simple change results in an algorithm that is asymptotically optimal, and provably outperforms standard EI by an order of magnitude.

2 - Information Relaxation and a Duality Based Learning Approach for Stochastic Dynamic Programs

Nan Chen, Chinese University of Hong Kong, Shatin N.T, Hong Kong, nchen@se.cuhk.edu.hk, Xiang Ma

We use the information relaxation technique to develop a duality based recursive approach to obtaining and improving confidence interval estimates for the true value of stochastic dynamic programming problem with finite time horizon. In addition to the advantage that the dual gap can help us assess the quality of the current control policy, the new proposed method also uses it to guide policy exploration in order to address the trade-off between exploration and exploitation.

3 - Extreme Event Estimation via Distributionally Robust Optimization

Yuanlu Bai, Columbia University, New York, NY, United States, yb2436@columbia.edu, Henry Lam

A bottleneck in analyzing extreme events is that, by their own nature, tail data are often scarce. Conventional approaches fit data using justified parametric distributions, but often encounter difficulties in confining both estimation biases and variances. We discuss approaches using distributionally robust optimization as a nonparametric alternative that, through a different conservativeness-variance tradeoff, can mitigate some of the statistical challenges in estimating tails. We explain the statistical connections and comparisons of our framework with conventional extreme value theory.

4 - Optimal Transport Based Distributionally Robust Optimization

Fan Zhang, Stanford University, Stanford, CA, 94305, United States, fzh@stanford.edu, Jose Blanchet, Karthyek Murthy

In this talk, we explain why optimal transport based Distributionally Robust Optimization (DRO) is an important class of stochastic optimization problems by showing that it encompasses a large class of estimators in machine learning. Our discussion will motivate a more general and powerful class of machine learning estimators and DRO formulations. We will provide optimal algorithms for the solution of these general DRO formulations. Finally, we will demonstrate empirically that our proposed methodology is able to improve upon a wide range of popular machine learning estimators.

■ TB68

S- University

Urban Air Transport I

Emerging Topic: Sharing Economy & Crowdsourcing

Emerging Topic Session

Chair: Jon Petersen, Uber Technologies, San Francisco, CA, 94107, United States

1 - How to Model City Soundscape Using Machine Learning

Alireza Rostamzadeh, Uber Technologies Inc., San Francisco, CA, United States, rostamzadeh.ar@gmail.com

Once Aerial Ride-sharing is deployed at scale, noise becomes the most important bottleneck in limiting the number of operations. To plan ahead, we developed the first-ever ML-based prediction model that can predict noise levels in dB for any given time and location. We collected training data in Dallas area using our custom-made noise sensors and used internal and external datasources to generate the most important and relevant features. Our model has a good accuracy and will be incorporated in our decision making process.

2 - Assessing Induced Demand for Metropolitan Air Service: A First-order Approach

Hani S. Mahmassani, Northwestern University, Transportation Center, Evanston, IL, 60208-4055, United States, masmah@northwestern.edu, Haleh AleAhmad, Ying Chen

Major congestion discourages many travelers from participating in important activities they wish to engage in at the locations they prefer. We present a first-order approach to estimate the potential induced demand for air service at the metropolitan area level. A supply side analysis is performed to identify travel corridors most likely to experience service improvement. The elasticity of demand with respect to travel time is estimated, and applied to predict the potential induced demand for different air service network configurations.

■ TB69

S- Seneca

Jonit Session Telecom & Network Analysis/Practice Curated: Agent-Based Models

Sponsored: Telecommunications and Network Analytics

Sponsored Session

Chair: Abdullah Konak, Penn State Berks, Reading, PA, 19610, United States

1 - Assessing Cooperative and Competitive Strategies Between Transit Agencies and Transportation Network Companies Using an Integrated ABM-DTA Software

Omer Verbas, Argonne National Laboratory, Lemont, IL, United States, omer@anl.gov, Joshua Auld, Michael Hyland, Felipe de Souza

In this study, we will model the potential short- and long-term responses by transit agencies in a world of connected and autonomous technologies and transportation network companies (TNC). The short-term responses comprise schedule optimizations in order to coordinate with TNCs better or compete against them better. The long-term responses comprise major changes e.g. adding/removing routes or modifying existing routes. The optimized scenarios will be tested in a unified framework using POLARIS; an agent-based ABM-DTA software consisting of an activity-based model integrated with multimodal routing, assignment and simulation.

2 - A New Adaptive Simulation Framework for Resilience Analysis of Interdependent Critical Infrastructures

Leili Soltanisehat, University of Oklahoma, Norman, OK, United States, leili.soltanisehat@ou.edu, Shima Mohebbi

We propose a hybrid simulation-optimization framework to assess the resilience of interdependent water, transportation, and cyber (traffic management system) critical infrastructures under random failure scenarios. The proposed framework consists of bottom-up (agent-based modeling) and top-down (system dynamics) methods to capture different layers of resiliency including physical and organizational resiliency. The main contributions of this research are: a) adding heterogeneity to the transportation network using Bayesian Inference method, and b) proposing a new cascading failure algorithm which considers functional and spatial interdependencies between networks.

3 - On the Performance of Consensus Algorithms in Blockchain

Sichao Yang, CEO and Co-Founder, Nakamoto & Turing Labs, New York, NY, United States, ysc@ntlabs.io, Lei Zhang, Chong Li

Consensus algorithm, by which agents in a blockchain consent on the order of transactions, is one of the key components to the security. As the advance of blockchain technologies, variant consensus algorithms have been proposed for different purposes. In consensus algorithms design, there are tradeoffs among security, decentralization, and performance. The capacity of a blockchain system is not only limited by the physical constraints, but also by the performance of consensus algorithms. We use agent-based model as a tool for simulating many types of consensus algorithms, and compare them by presenting analytical and simulation results, which is instrumental to the design of blockchains.

4 - Agent-Based Tree Search

Abdullah Konak, Penn State Berks, Tulpehocken Road, Reading, PA, 19610, United States, konak@psu.edu

An agent-based simulation model is proposed to explore an unknown tree with arbitrary edge distances by a set of agents which are initially located at the root of the tree and expected to return back to the root after all nodes are explored. The proposed algorithm depends only on local information stored at nodes using a bookkeeping token left at nodes by agents.

■ TB70

S- Jefferson A

Economics of Information Systems

Sponsored: EBusiness

Sponsored Session

Chair: Zhe Zhang, University of Texas at Dallas, Richardson, TX, 92617, United States

1 - "Un"fair Machine Learning Algorithms

Runshan Fu, Carnegie Mellon University, Pittsburgh, PA, 15217, United States, runshan@cmu.edu, Manmohan Aseri, Param Vir Singh, Kannan Srinivasan

Several new fairness notions have been proposed in response to the concern on the bias against certain demographics in algorithm-based decisions. In this paper, we model a data driven decision making process and compare optimal decisions for a firm under different fairness constraints, including the current law of equal treatment and two other popular notions, equal opportunity (EO) and demographic parity (DP). We show that, EO and DP, despite being conceptually appealing, can make everyone worse off, including the very group they aim to protect. This is because under these constraints, the firm would choose lower levels of learning effort and therefore be more conservative in selecting candidates.

2 - Is More Always Merrier? Procuring Impressions from Multiple Ad-exchanges

Leila Hosseini, The University of Texas at Dallas, Richardson, TX, 75080, United States, Shaojie Tang, Vijay S. Mookerjee

In this study, we analyze a procurement model for an ad-firm. There are two key decisions that the firm needs to make. First, it needs to select the set of mobile ad-exchanges to obtain its supply. Each mobile ad-exchange is characterized by specific supply uncertainties, location dependent win-curves, and a participation constraint. Second, for each ad-exchange and location, the ad-firm needs to determine its bidding policy, i.e., how much to bid for each bid-request.

3 - Reveal or Conceal? An Analysis of Inventory Reveal Policy in Online Flash Sales

Zibo Liu, University of Washington, Seattle, WA, 98105, United States, zibol@uw.edu, Shi Chen, Kamran Moinzadeh, Yong Tan

Inventory management is an important factor for companies to optimize their profit. Herding effect, scarcity effect and time pressure are essential ways that consumers' strategic behavior affect firms' decision. In this paper, we focus on inventory reveal policy on online flash sales platforms. Many flash sales platforms reveal inventory at all time, while others reveal inventory information only when the product has low inventory level. We build a model on inventory reveal problem and study three different inventory reveal policies: always conceal, always reveal, and a threshold policy. We compare their performance and find out how much the optimal policy can make the firm better off.

4 - Technological Disruption That Redefines Consumption: An Examination of Digital Camera Market Through Diffusion Lens

Geng Sun, University of Texas at Dallas, Richardson, TX, United States, gengs@utdallas.edu, Byungwan Koh, Srinivasan Raghunathan

The simultaneous decline in sales of digital cameras and boom of smartphones in recent years have triggered an intensively debatable question among industry experts: whether smartphones will replace digital cameras? Drawing from multi-generation diffusion literature, we show that smartphones are not a subsequent generation of digital cameras in general; however, smartphones disrupt the digital camera industry in a unique way that they have taken away the demand of compact digital cameras that could have migrated to dedicated digital cameras. In addition, we find that the rise of photo-sharing apps lately alleviates the disruption of smartphones.

5 - Commercializing Software Applications under Perpetual

Licensing: Is Seeding Still Relevant in the Age of Time-limited Freemium?

Hao Hu, Georgia Institute of Technology, Atlanta, GA, 30309, United States, Hao.Hu@scheller.gatech.edu, Marius Florin Niculescu, Yifan Dou, Dongjun Wu

The seeding strategy is losing its popularity to the time-limited freemium (TLF) in the software industry. This study seeks to answer when seeding is still relevant for practitioners. We compare seeding with TLF in a two-period game theoretical model, incorporating social learning, individual depreciation, and imperfect self-learning altogether. The findings suggest that seeding is optimal only if the majority of consumers significantly underestimate the software a priori. This finding is robust under different levels of imperfect self-learning and social learning.

■ TB71

S- Jefferson B

BOM Best Working Paper

Sponsored: Behavioral Operations Management

Sponsored Session

Chair: Mirko Kremer, Frankfurt School of Finance and Management gGmbh, Frankfurt, 60322, Germany

1 - Mitigating the Negative Effects of Customer Anxiety through Access to Human Contact

Michelle A. Shell, Harvard Business School, Norwood, MA, 02062, United States, Ryan Buell

Through a series of lab and field experiments, conducted in the high-anxiety domain of financial services, we document the negative effects of anxiety on customer performance and demonstrate how providing customers with access to human contact can improve customers' willingness to engage, elevate choice satisfaction and engender trust in companies.

2 - The Impact of Behavioral and Economic Drivers on Gig Economy Workers

Park Sinchaisri, The Wharton School, Jon M. Huntsman Hall, Philadelphia, PA, 19104, United States, Gad Allon, Maxine Cohen

Please check the mobile app for this abstract.

3 - Multi-Period Inventory Management with Budget Cycles: Rational and Behavioral Decision Making

Michael Becker-Peth, Rotterdam School of Management, Erasmus University, Burgemeester Oudlaan 50, Rotterdam, 3062 PA, Netherlands, Kai Hoberg, Margarita Protopappa-Sieke

We examine inventory decisions in a multiperiod newsvendor model. In particular, we analyze the impact of budget cycles in a behavioral setting. We derive optimal rational decisions and characterize the behavioral decision-making process using a shortsightedness factor. We test the aforementioned effect in a laboratory environment. We find that subjects reduce order-up-to levels significantly at the end of the current budget cycle, which results in a cyclic pattern during the budget cycle. This indicates that the subjects are shortsighted with respect to future budget cycles. To control for inventory that is carried over from one period to the next, we introduce a starting-inventory factor and find that order-up-to levels increase in the starting inventory.

■ TB72

S- Columbia

Computational Research in IS

Sponsored: Information Systems

Sponsored Session

Chair: Yicheng Song, University of Minnesota, Minneapolis, MN, 55455, United States

1 - Show Me Your ``Shares": Stochastic Social Promotion for Influence Maximization

Shaojie Tang, University of Texas at Dallas, McKinney, TX, 75071-5138, United States, shaojie.tang@utdallas.edu

Recent days have witnessed a boom of online firms that offer a ``Shares for Gifts" contest to users who need to share the product information with their friends in social network to gain rewards. During this campaign, the firm is faced by the problem of determining the set of initial users and the amount of rewards offered to each of them. In this paper, we formulate this problem as a stochastic social promotion problem. Our objective is to strategically offer rewards to some ``initial users" so as to maximize the influence spread.

2 - The Value of Alternative Data in Credit Risk Prediction: Evidence from a Large Field Experiment

Tian Lu, Carnegie Mellon University, Pittsburgh, PA, United States, tianlu@andrew.cmu.edu, Yingjie Zhang, Beibei Li

This paper conducts a comprehensive evaluation of the value of alternative data on microloan platforms with a large field experiment. Our machine-learning analyses demonstrate that alternative data can significantly improve the prediction accuracy of borrowers' default behavior and increase platform profits. Moreover, we find that our framework helps financial institutions extend service to more lower-income and less-educated loan applicants from less-developed geographical areas. Our study demonstrates the tremendous potential of leveraging alternative data to alleviate such inequality in the financial service markets, while in the meantime achieving higher platform revenues.

3 - A Recurrent Multivariate Marked Point Process Model for Player Engagement in Video Game

Junming Yin, University of Arizona, Management Information Systems Department, Tucson, AZ, 85721, United States, Zisu Wang, Tianyu Gu, Yong Liu

The strategic management of game development relies on the understanding of the behavior dynamics of players. In this study, we propose an innovative approach combining marked point processes and recurrent neural network to capture players' activity dynamics. Applying our model to an American football video game data set, we find that players' previous game sessions are a major driver for their future activities, whereas previous purchases only account for a small portion of influence for their future engagement. Out-of-sample prediction results further demonstrate that our model can achieve better performance in predicting the time, type, and side-information of players' future activities.

4 - Cold Start and Hard Stop Recommendation: A Dynamic Graph Neural Network Approach

Meizi Zhou, University of Minnesota, Minneapolis, MN, United States, zhou0793@umn.edu, Yicheng Song, Zhuoxin Li, Chunmian Ge

Online personalized recommendation for time-constrained products (e.g. news, short video, flash sale,...) is a highly challenging problem due to the dynamic nature of continuous influx of new items into the market and fade out after limited life cycle. In such markets, the recommender system faces constant cold start problems as well as the need to take prompt actions before the items expire. To address these challenges, we propose a dynamic graph neural network recommendation framework, which aims to explicitly model the sequential user-item interaction to incrementally update the bipartite graph between user and item using recurrent neural network.

5 - Network Embedding Based Recommendation with a Neural Attention Model

Yuheng Hu, University of Illinois-Chicago, Chicago, IL, 60607, United States, Tengteng Ma, Yingda Lu, Sid Bhattacharyya

Heterogeneous information has been widely used to extract context information in modeling recommender systems. Although some recent work has achieved performance improvement to some extent, when it comes to model interactions between entities, they still resorted to matrix factorization. By developing a novel deep neural network based on network embedding and involving attention mechanism, we present a framework that can model complex context information and provide interpretations for the recommendation.

■ TB73

S- Boren

OR at Facebook

Sponsored: INFORMS Section on Practice

Sponsored Session

Chair: Jingyang Xu, Facebook Inc, Menlo Park, CA, 94025, United States

Co-Chair: Nicolas Stier

1 - Network Planning for Connectivity at Facebook

Birce Tezel, Facebook, Menlo Park, CA, United States, btezel@fb.com, Erik Zawadzki

Facebook Connectivity aims to bring more people online to a faster internet. In Advanced Network Planning, we build automated planning tools to help our partners create desirable plans in minutes that previously would have taken days. Dense urban planning designs 60 GHz wireless mesh networks that provide fiber speed connectivity at a fraction of the deployment cost. The tool has been helpful for Terragraph deployments in Georgetown. Fiber planning involves solving graph subset problems based on right-of-way graphs. One of our tools solves a form of the survivable network design problem. We use a heuristic that has good empirical performance and is able to scale to large cities like Lagos, Nigeria.

2 - Tetris Planner: Optimizing Facebook Data Warehouse Data Placement

Han Fang, Data Scientist, Facebook, Seattle, WA, United States, Dorian Jaminais, Delia David, Jeff Tian, Martin Valdez-Vivas, Amol Desai, Waqar Malik

Facebook's data warehouse has 9+ data centers around the world, which hosts exabytes of data for analytics and machine learning. Due to uneven growth of namespaces, there were a mix of highly loaded and half empty clusters w.r.t storage, compute, IO, and network. We built Tetris Planner, a system to plan for load rebalancing through daily table placement instructions and partitions moves. The core of Planner is the optimization algorithm with mixed integer linear programming. It tries to solve the minimax optimization problem, as to minimize the maximum utilization across multi-objectives. Planner was deployed to all Facebook's data centers and successfully rebalancing petabytes of data daily.

3 - Planning Spare Parts in Data Center

Tianke Feng, Research Scientist, Facebook, Inc., Menlo Park, CA, United States, Jingyang Xu, Bowen Hua

A challenge to provide high availability and low latency service in modern data centers is to handle the bursts of part failures. To minimize service disruption, certain quantity of spare parts must be planned beforehand, with proper trade-off between the risk of shortage and the cost of overstocking. Part failures are highly uncertain, complicated by the quality of service, correlation across parts, temperatures, load balancing, etc. In this work, we analyze the patterns of part failures and discusses machine learning based forecasting models and the inventory control policies.

4 - Matching Algorithms for Blood Donation

Duncan McElfresh, Facebook, Menlo Park, CA, United States, dmcelfre@math.umd.edu, Christian Kroer, Sergey Pupyrev, Eric Sodomka, John P. Dickerson

Managing the blood supply chain has been a topic of research for decades; we focus on an aspect of this problem rarely studied in the literature: coordinating blood donors to meet demand. We model this problem as a matching market: donors are matched to donation centers by a central planner, who prompts individual donors (e.g., via push notification) to donate to a preferred center or centers. Donors may have constraints or preferences that can be taken into account. We present an initial analysis of policies for matching potential blood donors to donation centers under these constraints and preferences, and under simple models of stochastic demand.

■ TB74

S- Capitol Hill

Tips for Successful Publication

Sponsored: Junior Faculty JFIG

Sponsored Session

Chair: He Wang, Georgia Institute of Technology, Atlanta, GA, 30332-0205, United States

Co-Chair: Zhijie Dong, Texas State University, San Marcos, TX, 78640, United States

1 - Tips for Successful Publication

Zhijie Dong, Texas State University, San Marcos, TX, 78640, United States, sasha.dong@txstate.edu

Current editors from INFORMS journals will share tips on how to get your paper successfully published, from selecting the right journal to preparing and finalizing the manuscript.

Panelists

- Alice E. Smith, Auburn University, Dept of Industrial/Sys Engineering, Auburn, AL, 36849, United States, smithae@auburn.edu
- Shane Henderson, Cornell University, Ithaca, NY, 14853, United States
- Martin Savelsbergh, Georgia Tech, Atlanta, GA, United States, martin.savelsbergh@isye.gatech.edu
- Christopher S. Tang, University of California-Los Angeles, UCLA Anderson School of Management, Operations and Technology Management, Los Angeles, CA, 90095-1481, United States

■ TB75

S- Metropolitan Ballroom A

Flash Session II

Flash Session

Chair: Barbara Fasolo, London School of Economics, Department of Management, Houghton Street, London, WC2A 2AE, United Kingdom

1 - Architecting A Real-time Optimization Framework for Driver Positioning

Hao Yi Ong, Lyft, San Francisco, CA, United States, hong@lyft.com

Personal Power Zones (PPZs) are Lyft's real-time supply-shaping incentive that proactively repositions drivers in anticipation of demand. This paper describes a positioning algorithm for PPZs that balances between optimizing ride throughput and driver retention subject to uncertainty in the supply and demand distributions and response. The algorithm generates moneyed driver bonuses and guidance, and is based on solving a series of convex programs. The method scales well and positions drivers efficiently, generating significant incremental rides for both drivers and their markets.

2 - Bekaert Predicts Total Market Demand Using Macroeconomic Indicators to Improve the Tactical Sales Forecast

Gylian Verstraete, Researcher/Consultant, Ghent University, Ghent, Belgium, gylian.verstraete@ugent.be, El-Houssaine Aghezzaf, Bram Desmet

Traditional forecasting methods extrapolate historical patterns to predict future sales. These forecasting models are incapable of anticipating macroeconomic changes. To account for these, literature suggests including leading macroeconomic indicators in this process. Events that result in market share fluctuations often hinder this process. Furthermore, companies upstream in the supply chain are unable to segment their sales based on the end-market. We address this by forecasting total market demand. We decompose the market demand after which the extracted trend is forecasted using macroeconomic indicators. The demand is used as an indicator for predicting the company sales.

3 - Classifying Seat Pan Contours Using Principal Component Analysis and Density-based Clustering

Joan Martinez, Western Michigan University, Kalamazoo, MI, United States, Steven Butt, Tycho Fredericks

Numerous studies on sitting comfort/discomfort have been conducted over the years, but knowledge about the influence of seat pan parameters (e.g., surface, geometry) on comfort/discomfort is still inconclusive. Research was conducted to investigate the influence of a user-adjustable seat pan during a seated computer-task environment. Two hundred and forty-four user-adjusted seat pan contours were obtained and analyzed using principal component analysis and density-based clustering techniques. Four distinct shapes of seat pan contours were obtained based on type of sitter. Future research aims to investigate factors that could explain seat pan contour preferences by subjects.

4 - Defaults: Do They Save Every Life Equally?

Barbara Fasolo, London School of Economics, Department of Operational Research, Houghton Street, London, WC2A 2AE, United Kingdom, Elena Reutskaja

Opt-out defaults applied to healthcare save lives - but do they save every life equally? Our artefactual field experiment on hospital choice and simulations with knee replacement mortality ratios show that defaults create a disconcerting inequality: citizens with higher ability to use numbers ("numeracy") are saved more than low numerates. This finding is critical for world-wide healthcare managers and policy makers.

5 - A Stochastic Model for Casualty Transportation in Large Scale Disasters: An Application for Istanbul

Sule I. Satoglu, Professor, Istanbul Techical University, Istanbul, Turkey, onbaslis@itu.edu.tr, Nadide Caglayan

Casualty transportation is a vital issue in cases of large scale disasters. In this study, a two-stage stochastic model is proposed, where the number injured people (from each triage category) transported from each triage point to the hospitals and temporary medical centers, the number of tours of ambulances and number of casualty could not be served are decided, according to each scenario. The model is solved for the expected Istanbul Earthquake, especially for Kartal district of Istanbul, based on real population, expected casualty, hospital location and capacity data.

■ TB76

S- Metropolitan Ballroom B

Operations Management IV

Contributed Session

Chair: Jianjun Xu, Dongbei University of Finance and Economics, Dalian,, 116025, China

1 - Optimal Timing and Rollover Strategy of New Product Introduction: Newsvendor Perspective

Jian Li, Northeastern Illinois University, Chicago, IL, United States, j-li3@neiu.edu, Panos Kouvelis

This paper studies the optimal timing of a new product introduction and the optimal product rollover strategy. Our focus is on characterizing the optimal policy, identifying the environments each strategy works best, and estimating numerically the impact of other factors on the benefit of Dynamic.

2 - Product Assortment and Space Allocation Strategies to Attract Loyal and Non-loyal Customers

Anna Timonina-Farkas, Postdoctoral researcher, EPFL, TOM, Lausanne, Switzerland, anna.farkas@epfl.ch, Argyro Katsifou, Ralf W. Seifert

Assortment planning has received much attention from practitioners and academics due to its direct impact on retailers' commercial success. We focus on the increasingly popular retail practice of using combined product assortments consisting of regular "standard" products and more fashionable "variable" products, included to increase the store traffic and to drive up the sales. We address the assortment planning as a bilevel optimization problem, where the retailer's binary decision about product inclusion influences the distribution of product's demand, i.e. we focus on decision-dependent uncertainties.

3 - Optimal Sourcing Strategies Based on a Real Option

Jae Hyeok Jo, Master's Course, KyungPook National University, DaeGu, Korea, Republic of, Sung Su Kim

Evaluation of outsourcing suppliers is one of complex business problems because of uncertainty and dynamic changes of operating environments. A firm should continuously assess its partners from multiple aspects to be competitive. At the same time, its supply chain should be agile enough to implement sourcing strategies derived from assessments of partners. We propose a model for an optimal sourcing strategy based on a real option. The model considers environmental and firm-specific factors which are related to cost. Uncertainties are modeled using Brownian motion and Monte Carlo simulation.

4 - Decision Making in the Context of Flexible Demand

Sepideh Alavi, PhD Candidate-Supply Chain & Operations Management, University of Wisconsin Milwaukee, Milwaukee, WI, United States, alavi@uwm.edu, Matthew Petering, Xiaohang Yue

We consider applications of the concept of flexible demand in various domains. In an inventory setting, we study a cyclic coordinated supply and replenishment problem with batch supplies and flexible demand. The decisions include the timing and sizes of batches delivered by the suppliers to the buffer and the timing and amounts by which demanders are replenished in order to minimize total cost. We also introduce the Vehicle Routing Problem with Flexible Demand (VRP-FD). Math models and heuristic methods are presented and discussed.

5 - Display and Product Positioning Optimization for Online Retailers

Alara Tascioglu, Koç University, Istanbul, Turkey, atascioglu17@ku.edu.tr, Gurhan Kok, Selcuk Karabati

Consumers face a long list of products when searching for a product online. The location of a product in the page layout affects the customer choice process. Thus, an optimized product positioning can potentially increase consumer satisfaction as well as company profits. We develop a display location based Multinomial Logit model to determine product positions in the first page of an online store. We compare our results with commonly used heuristics.

6 - Optimal Dual Sales and Stock Replenishment by Flexible Contracts with Spot Markets

Jianjun Xu, Associate Professor, Dongbei University of Finance and Economics, Dalian,, China, xujianjun@dufe.edu.cn, Mustafa Çagri Gurbuz, Youyi Feng, Shaoxiang Chen

We consider a company that uses two channels for trading: long-term contracts and spot markets. A fixed setup cost is incurred in each instance of buying or selling in the spot market. This paper considers very general inventory-related (not necessarily convex) costs, and demand is random following a one-sided Polya distribution. We show that the optimal policy can be characterized by five critical points. We also characterize optimal procurement from the contract supplier under certain conditions. Moreover, we show that our results also apply to uniform demand, and numerical tests assuming uniform demand are performed to discern which factors are most important and to gain managerial insights.

■ TB77

S- Fremont

Scheduling II

Contributed Session

Chair: Ayaka Yamamoto, Kansai University, 3-3-35, Yamate-cho, Suita-city, Osaka, 5648680, Japan

1 - Learning Dispatching Rules from Optimal Schedules for Single Machine Scheduling Problems

Sungbum Jun, Purdue University, West Lafayette, IN, United States, Seokcheon Lee

Designing efficient and robust dispatching rules is crucial to respond to changes on the shop floor. However, due to the increasing volume of data from multiple sources, it is difficult to capture implicit rules intuitively. Therefore, we propose a novel approach for single machine scheduling based on a decision tree expressed in a set of IF-THEN rules. The proposed approach generates a dispatching rule from optimal schedules that contain the knowledge of why one job is dispatched ahead of another. Also, genetic programming is applied to extract new features by combining attributes. The major contribution of this study is discovering understandable dispatching rules with less human intervention.

2 - Online Scheduling on a Single Parallel Batch Machine with a Temporary Interruption

Ran Lin, Northwestern Polytechnical University, Xi'an, China, pacpos.rlin@gmail.com, Junqiang Wang

We consider the online scheduling problem on a single parallel batch machine with a temporary interruption. Jobs arrive over time, and the information of jobs becomes known at its arrival time. A parallel batch machine can process at most b jobs simultaneously. When the interruption occurs at time T, the processing of jobs has to be stopped and restarted after time T. Our goal is to minimize the makespan. We prove that there is no deterministic online algorithm with a competitive ratio less than 2 for the arbitrary positive integer b. Furthermore, we provide a best online algorithm H(b). When b=1, 2 and $b \geq n$, we show that H(b) is best possible. When $3 \leq b < n$, we prove that the competitive ratio of H(b) is 2.5.

3 - Scheduling in Permutation Flowshops to Obtain an Optimal Solution/ A Lower Bound with the Consideration of the Makespan of Jobs

Thamarassery Abdul Jaleel Jessin, Research Scholar, Indian Institute of Technology Madras, Chennai, India, tajessin2008@yahoo.co.in, Chandrasekharan Rajendran, Sakthivel Madankumar

This paper focuses on developing lower bounds/optimal solutions for N-job M-machine permutation flowshop scheduling problems with the objective of minimizing makespan using Lagrangean Relaxation technique. We develop an MILP based Lagrangean Relaxation model with the consideration of benchmark problem instances to evaluate the performance of the model. It is observed that the proposed method gives encouraging good results.

4 - Makespan Minimizing for a Sequence-dependent Flowshop with Machine Deterioration and Maintenance Events

Fatma Alkhabbaz, Kuwait University-Kuwait, Kuwait, M'Hallah Rym

This paper addresses the two-machine permutation flowshop scheduling problem, where idle time is allowed on the second machine. The objective minimizes the makespan of a set of jobs whose processing times are sequence-dependent. The machines are subject to deterioration but may be restored to a perfect state via maintenance events. The maintenance duration is fixed and known. This paper models the problem as a non-linear mixed integer program that can solve small instances. For larger instances, the paper proposes four heuristics. Each heuristic constructs a sequence using a priority rule and inserts maintenance events using a mixed integer program.

5 - Process Innovation of Synchrotron Radiator Using Time Indexed Single-machine Scheduling

Myungho Lee, POSTECH IME, Nam-gu, Pohang-si, Korea, Republic of, Kangbok Lee, Jiang Xiao Juan

Synchrotron radiator is a microscope used for a variety of research areas such as biology and material science. In spite of its increasing importance, there is no research on how to operate it. This research provides an optimization method for a synchrotron radiator scheduling problem, called a beamline management. We formulate it as a time-indexed MIP model for a realistic setting and solve it optimally in a short time. We also find and analyze an important criterion of robustness against an unexpected disaster, which minimizes the maximum weight of jobs affected by a disaster with a certain length. We formulate this special problem, develop algorithms, and prove optimality for some special cases.

6 - Tunnel Maintenance Scheduling for Leveling Annual Cost in Japan

Ayaka Yamamoto, Kansai University, Osaka, Japan, k900324@kansai-u.ac.jp, Hiroshige Dan, Hiroaki Tanaka-Kanekiyo, Masakazu Sakou, Naoki Satou

In Japan, when tunnel maintenance is conducted, the guideline which was established by the Japanese government must be followed. Japanese local governments prefer to level the annual cost as much as possible, since local governments generally adopt the single-year budget system and imbalance of annual costs may cause a shortage of the annual maintenance cost. In this research, we propose an optimization model for making maintenance schedule of tunnels to reduce the imbalance. Also we conducted some numerical experiments with the practical data and confirmed the effectiveness of the model.

■ TB78

S- Greenwood

Joint Session DEA/Practice Curated: Applications in DEA II

Emerging Topic: Productivity, Efficiency and Data Envelopment Analysis

Emerging Topic Session

Chair: Timothy R Anderson, Portland State University, Portland, OR, 97201, United States

1 - Sustainability and Energy Efficiency in Indian Manufacturing

Kankana Mukherjee, Babson College, Economics Division, Wellesley, MA, 02481, United States, kmukherjee@babson.edu

A major crisis facing the Indian economy is in terms of significant energy shortage. Given the supply constraints and heavy dependence on imports for energy, a sustainable growth path for the manufacturing sector depends on achieving efficiency in energy use. This paper examines the energy intensive industries in India over the period 2008-09 through 2015-16 and utilizes Data Envelopment Analysis to study sustainability and energy efficiency in Indian manufacturing. The roles of technical efficiency of production, capacity utilization, adoption of energy efficient technology and other factors in determining energy efficiency and a sustainable growth path for these industries are analyzed.

2 - Output Attributes and Hedonic Prices: An Analysis of Airfares

Charles Howell, Autonomous University of Barcelona, Barcelona, Spain, Charles.Howell@uab.cat, Emili Grifell-Tatjé

The man objective of the paper is to study the effect of product differentiation on price formation in the airline industry. For this purpose, we introduce a Konüs (1939) type index of output attributes as a measure of the level of product differentiation in a market. The definition of the Konüs output attribute index is based on cost functions, which capture the cost differential of providing varying levels of output attributes. We then use the Konüs output attribute index, along with measures of market power, to explore how adding market characteristics to a hedonic price model can improve the usability of results. The model is empirically tested on US domestic airfare data.

3 - Regulation under Asymmetric Information in Road Transport Networks

Jung You, California State University-East Bay, Hayward, CA, 94542, United States, jung.you@csueastbay.edu

This paper is concerned with the analysis of regulations on a monopolistic public enterprise. We construct a game-theoretical contract model between the government and a public enterprise where the regulated firm holds private information about its cost-efficiency. Based on the theoretical model, we evaluate the welfare consequences of regulatory policies in road transport network. Our empirical analysis is to estimate our structural contract models including the travel demand function, cost function, and optimal subsidy function, and use the estimates to study the welfare implications of price and subsidy-based regulation policies.

4 - Exploring the Impact of Noise on DEA

Maoloud Dabab, Portland State University, Portland, OR, 97219, United States, dabab@pdx.edu, Timothy Anderson

The impact of random production values is explored in DEA using an application of baseball batting through historical data. Varying patterns of noise across time are shown and related to application characteristics.

■ TB79

S- Issaquah A

Applying Advanced Analytics to Improve Seed Development Decisions

Emerging Topic: Agriculture

Emerging Topic Session

Chair: Guiping Hu, Iowa State University, Ames, IA, 50011, United States

Co-Chair: Lizhi Wang, Iowa State University, Ames, IA, 50011, United States

1 - Response Surface Analysis of Genomic Prediction Accuracy Values Using Quality Control Covariates in Soybean

Reka Howard, University of Nebraska-Lincoln, 342B Hardin Hall, Lincoln, NE, 68583, United States

An important tool in plant breeding programs is genomic prediction (GP). In GP molecular marker information and phenotypic data are used to predict the phenotype of individuals for which only marker data are available. Higher prediction accuracy can be achieved by using quality data. The quality control of marker data includes the elimination of markers with certain level of minor allele frequency (MAF), missing marker values and the imputation of missing marker values. We evaluated accuracy in terms of the combination of 12 MAF values, 27 different percentages of missing marker values, and 2 imputation techniques. We constructed a response surface of prediction accuracy values using soybean data.

2 - Using Harshness to Identify Stable Plant Varieties

Hanisha Vemireddy, Iowa State University, Ames, IA, United States, hanisha@iastate.edu, Sigurdur Olafsson

One of the important aspects in plant breeding is to understand the quality of an environment in which plant varieties are planted. In this paper, we propose an empirical harshness index for different environments based on phenotype data, and develop visualizations to use this index to better support advancement decisions.

3 - Crop Stress Classification Using Deep Convolutional Neural Networks

Saeed Khaki, Iowa State University, Ames, IA, 50010, United States, skhaki@iastate.edu

As one of the winning teams in 2019 Syngenta Crop Challenge, we designed a two-step approach to classify 2,452 corn hybrids as either tolerant or susceptible to heat and drought stresses. First, we designed a deep convolutional neural network that took advantage of state-of-the-art modeling techniques to extract stress metrics for each type of stress. Then, we conducted a linear regression of the yield of hybrids against each stress metric, and classified the hybrids based on the slope the regression line, since the slope of the regression line showed how sensitive a hybrid was to a specific environmental stress. Our results suggested that only 14% of hybrids were tolerant to at least one type of stress.

4 - Multi-trait Genomic Selection Methods for Crop Improvement

Saba Moeinizade, Iowa State University, Ames, IA, 50014, United States, sabamz@iastate.edu, Aaron Kusmec, Guiping Hu, Lizhi Wang, Patrick Schnable

Productivity in plants depends on more than one trait. Hence, the decision-maker should consider several characteristics to decide which individuals are the most valuable ones to be parents of the next generation. Finding the best selection strategies to reach breeding goals in a Multi-trait Genomic Selection (MTGS) framework is a key issue in plant breeding. This research introduces an approach for MTGS problems by optimizing the main goal of a breeding project (i.e. high yield) while making sure other traits fall into a desirable range. We design a new MTGS algorithm using optimization and simulation techniques and examine the effectiveness of the algorithm compared to the conventional methods.

5 - New Algorithms for Detecting Multi Effects and Multi Ways Epistatic Interactions

Javad Ansarifar, Iowa State University, Ames, IA, United States, ansarifar.javad@gmail.com, Lizhi Wang

Detection of epistasis, which is the phenomenon of genetic interactions, is extremely challenging problem due to the combinatorial nature of the problem. We propose three new algorithms for multi-effect and multi-way epistases detection, with one guaranteeing global optimality and the other two being local optimization oriented heuristics. The comparison of computational performance of the proposed heuristic algorithm with several state-of-the-art methods revealed the proposed heuristic algorithm was much more effective and efficient than others at finding a close-to-optimal solution.

■ TB80

S- Issaquah B

Teams and Innovation Management

Sponsored: Technology, Innovation Management & Entrepreneurship

Sponsored Session

Chair: Nilam Kaushik, Boston, MA, 02115, United States

1 - Parallel Innovation Contests

Ersin Korpeoglu, University College London, 1 Canada Square, London, E14 5AA, United Kingdom, C. Gizem Korpeoglu, Isa Emin Hafalir

We study innovation contests where multiple organizers seek solutions from agents, and the quality of an agent's solution depends on her effort and uncertainty. We find that when uncertainty is sufficiently large, organizers benefit from agents' entry to multiple contests. An organizer's profit is unimodal in the number of contests, and the optimal number of contests increases with uncertainty. Thus, practitioners who seek innovative (resp., low-novelty) solutions may benefit from running multiple parallel contests and from encouraging (resp., discouraging) agents' entry to multiple contests.

2 - The Interplay Between Physical and Social Space on Collaboration

Manuel E. Sosa, Associate Professor, INSEAD, Singapore, 138676, Singapore, manuel.sosa@insead.edu, Massimo Maoret

Previous studies on collaboration have emphasized the role that intra-organizational networks play on organizational performance. Yet, these studies overlook the role that physical spaces, and in particular inter-personal distance, play in determining the effect of network structure on collaborative performance. We close this salient gap by taking advantage of a quasi-natural experiment, in which a global pharmaceutical firm relocated two of their regional offices onto new sites. By capturing both social network and inter- personal distances prior and after the moves, we study the interplay of social network structures and physical spaces on inter-personal collaborative performance.

3 - Communication Patterns At Academic Events Related to Scientific Collaboration Patterns

Jacqueline Lane, Harvard University, Boston, MA, United States, jnlane@hbs.edu

Good ideas often result from combining innovative ways of thinking from one field with those of another. We propose that academic networking events offer a context to "engineer" serendipitous encounters. To advance understanding, we designed and executed a research symposium at a leading research university held in conjunction with a grant opportunity. Scientists who engaged in "information sharing" networking sessions were more likely to collaborate with one another on the grant proposal. The extent of boundary-spanning ties in scientists' communication networks are also related to breadth in research interests.

4 - Gender-based Preferences for Tech Work: Field Experimental Evidence from an Internet-of-things Platform

Nilam Kaushik, Indian Institute of Management, Bangalore, 02115, India, Kevin Boudreau

We report on a large field experiment in which 112,770 U.S. university-educated individuals from all fields and career stages were given the opportunity to participate in a technologically intensive area of learning and innovation, the Internet-of-Things (IoT).

■ TB81

S- Kirkland

Optimization Methods for Design and Operation of Energy Systems

Sponsored: Energy, Natural Res & the Environment/Natural Resources Petrochemicals

Sponsored Session

Chair: YIFU Chen, University of Wisconsin Madison, Madison, WI, 53705, United States

1 - An Energy-water Nexus Approach for Energy Infrastructure Planning

Efstratios Pistikopoulos, Texas A&M Energy Institute, 1617 Research Parkway, 3rd Floor, Giesecke Engineering Research Bldg, College Station, TX, 77843-3372, United States, stratos@tamu.edu, R. Cory Allen, Styliani Avraamidou

Due to rapid global population and economic growth, the demand for energy and water is dramatically increasing. To address this challenge, we have developed an integrated capacity planning and operational scheduling framework for power generating and water treatment systems. The mixed integer programming model allows for the creation of additional water treatment facilities, power plants, and large-scale energy storage facilities to account for the intrinsic stochastic nature of renewable generators. We illustrate the effectiveness of the infrastructure expansion framework through the use of a case study that spans the ERCOT region of Texas.

2 - Optimization of Inter-regional Flows in Petrochemical Supply Chains

Arul Sundaramoorthy, BP, 150 W. Warrenville Road, Naperville, IL, 60563, United States

The petrochemical supply-chain network consists of production sites, demand locations and optional suppliers in various regions across the globe. The core demand of each region is typically assigned to production sites in that region. The spot demands are treated as common marketplace for all regions. The product can be stored at production sites with limited capacity. Given the costs of production and logistics as well as product prices, the goal of multi-period optimization model is to maximize the variable contribution margin for the entire network. The key decisions in each period include which site should produce how much, stock position in each location and optimal inter-regional flows.

3 - Data-driven Strategies for Optimization of Integrated Chemical Plants

Kaiwen Ma, Carnegie Mellon University, Pittsburgh, PA, United States, Nikolaos Sahinidis, Sreekanth Rajagopalan, Satyajith Amaran, Scott Bury

Operation optimization over large-scale integrated chemical plants is inherently a difficult problem for a system of such size and complexity. We propose two novel methodologies to exploit the available Aspen flowsheets and plant data. In the first approach, we develop and solve a data-driven optimization model. The impact of the level of detail of the model is investigated. In the second approach, we apply derivative-free optimization (DFO) with a novel decomposition framework. Our proposed framework significantly extends the scope of current DFO solvers to larger-scale problems. Both methodologies are studied and compared over the dimethyl ether/diethyl ether production case study.

4 - Variable Bounds Tightening for Multiperiod Blending Problem

YIFU Chen, University of Wisconsin Madison, Madison, WI, 53705, United States, Christos T. Maravelias

We introduce an algorithm for variable bounds tightening using multiple constraints in the context of Multiperiod Blending Problem, which is typically formulated as a nonconvex MINLP. We propose a reformulation for the variables involved in the bilinear terms through lifting and an algorithm to tighten the bounds on the lifted variables using linear constraints. The selection of constraints and the sequence of variable bounds to be tightened are based on the understanding of the physical system. We introduce RLT constraints that utilize the bounds to further tighten the formulation. We demonstrate the effectiveness of our methods through an extensive computational study.

■ TB82

S- Leschi

Analytical Work on Food Waste

Sponsored: Energy, Natural Res & the Environment/Environment & Sustainability

Sponsored Session

Chair: Dorothee Honhon, University of Texas at Dallas, Richardson, TX, 75080, United States

1 - Strategic Stockpiling in the Presence of Waste Cost

Benny Mantin, University of Luxembourg, Luxembourg, L-1511, Luxembourg, benny.mantin@uni.lu

We model the stocking decisions of a seller and its customers, who face uncertainty about their own consumption rates for a perishable good over a two-period horizon. We characterize the conditions leading to strategic consumer stockpiling and evaluate the impact of waste cost on consumers' and sellers' inventory decisions.

2 - How Do Minimum Life on Receipt (MLOR) Agreements Impact Food Supply Chains?

Sara Martins, INESC TEC and Faculty of Engineering, University of Porto, Porto, Portugal, Pedro Amorim, Bernardo Almada-Lobo

In food supply chains, retailers usually impose a minimum life on receipt (MLOR) to perishable products, which specifies the minimum shelf-life the retailer is willing to accept in the inbound. While these agreements are common in practice, there is a lack of literature on this criterion and how it impacts the supply chain, especially the food waste generated. Practical reports show that the mean MLOR is 85%, but there is no difference amongst products. This study models an agreement between a retailer and a manufacturer, considering different settings and MLOR values, assessing their impact in the supply chain. The goal is to analyze how the MLOR should be defined for distinct product categories.

3 - Implications of Eliminating Grading in Food Supply Chains

Karthik Murali, Assistant Professor, Oregon State University, Corvallis, OR, United States, karthik.murali@oregonstate.edu, Isil Alev

Motivated by the practice of grocery retailers beginning to sell ugly produce alongside conventionally aesthetic produce, we study production and distribution decisions in an agricultural supply chain to determine the social and environmental consequences of this global food movement. Our results identify profitability and sustainability implications of product-line decisions for grocery retailers and their consequences for upstream farmers.

4 - The Race for Product Renewal

Xabier Barriola, IESE Business School, Barcelona, 08034, Spain, xbarriola@iese.edu, Victor Martínez de Albéniz

Product renewal has been criticized for increasing waste. While consumers enjoy novelty in settings where product utility decays over time, it is not clear how firms should take renewal decisions when there are fixed costs associated with a new launch. In this work, we build a model where consumers decide to renew their products as a function of releases, and firms optimize features, pricing, and launches. We determine closed form optimal launch decisions in the case of a single firm, and derive equilibrium decisions under competition. We find that a monopolist internalizes inter-product cannibalization and sets efficient launch decisions, while competition results in an oversupply of new products.

■ TB83

S- Medina

New Challenges in Energy

Sponsored: Energy, Natural Res & the Environment/Electricity Sponsored Session

Chair: Ali Daraeepour, Princeton University, Princeton, NJ, 08544, United States

1 - Remuneration of Flexibility in Non-convex Electricity Markets: A PJM Case Study

Ali Daraeepour, Princeton University, 016 ACEE Building, 086 Olden St, Princeton, NJ, 08544, United States, a.daraeepour@princeton.edu

Continued growth in penetration of Variable Renewable Electricity (VRE) increases the demand for operational flexibility in electricity markets. Paradoxically, the price formation may not effectively remunerate the flexibility attributes of conventional generating units. While electricity markets are inherently non-convex, conventional pricing mechanisms assume convexity that results in prices that may not properly incent operational flexibility. This study evaluates the implications of conventional and convex hull marginal pricing mechanisms for the ability of markets in incenting flexibility with growing penetration of wind resources in PJM.

2 - A Mathematical Optimization Approach to Enhanced Renewable Energy Forecasting and Trading

Juan M. Morales, Associate Professor, University of Malaga, Malaga, Spain, juan.morales@uma.es, Miguel A. Muñoz, Salvador Pineda

In this talk, we describe a mathematical optimization approach to improve the day-ahead forecasts of stochastic renewable energy production, by exploiting information on auxiliary variables that may have some predictive power on such a production. Our approach is based on a data-driven reformulation of the well-known newsvendor problem and can be easily tailored to enhance the performance of renewable energy producers in a dual-price balancing market. We illustrate our approach using a realistic case study based on data from the Danish power system, where the auxiliary information our approach leverages corresponds, e.g., to the predicted renewable energy generation in neighboring regions.

3 - Absence of Spurious Local Trajectories in Time-varying Optimization

Cédric Josz, Le Kremlin-Bicetre, 14 A. Avenue du Docteur Antoine Lacroix, Le Kremlin-Bicetre, 94270, France

We study the landscape of optimization problems where the input data vary over time. To this end, we introduce the notion of spurious local trajectory as a generalization to the notion of spurious local solution in nonconvex optimization. As a case study, we consider the problem of optimal power flow in electrical networks with real-world and time-varying input data. We show that, despite the existence of spurious local solutions at every time, the time-varying landscape of the problem is free of spurious local trajectories. Inspired by this example, we propose an ordinary differential equation to study this phenomenon. (Joint work with S. Fattahi, R. Mohammadi, J. Lavaei, S. Sojoudi).

4 - Incentives for More Flexible Power Plant Operation under Different Market Designs

Christoph Weber, University Duisburg-Essen, Essen, Germany, christoph.weber@uni-due.de

Higher shares of variable renewables in power markets induce higher ramping needs and higher deviations between day-ahead schedules and actual production. To cope with these challenges, conventional power producers need to provide flexible response. Based on a stylized two-stage setting including both flexible and inflexible units, we analyze the pricing and the resulting incentives occurring in ISO-based American markets with complex, cost-based bids making use of convex hull pricing. We compare the incentives to those arising in European-style markets with simple bids and self-scheduling.

5 - The Impact of Renewable Energy Forecast Errors on Imbalance Volumes and Electricity Spot Prices

Shadi Goodarzi, University of Texas Austin, Austin, CA, United States, Derek W. Bunn, H. Niles Perera

Using data from the German electricity market, we investigate the effect of wind and solar energy forecasts' errors on imbalance volumes and intraday spot electricity prices. We use OLS and quantile regressions and autoregressive moving averages to identify these relationships using variables that have a quarter-hourly data granularity.

■ TB84

S- Ravenna A

Resilience in Energy and its Interdependent Systems

Sponsored: Energy, Natural Res & the Environment/Energy Sponsored Session

Chair: Charalampos Avraam, Johns Hopkins University, Baltimore, MD, 21218, United States

1 - Irrigation and Hydropower Tradeoff at the Intersection of Food-energy-water Nexus

Ying Zhang, Johns Hopkins University, Baltimore, MD, 21215-2623, United States, ying.zhang@jhu.edu, Prathibha Juturu, Sriram Sankaranarayanan, Carson Drew, Ben Zaitchik, Sauleh Ahmad Siddiqui

The Grand Ethiopian Renaissance Dam (GERD) will be the largest hydroelectric dam in Africa when complete. The great irrigation potential upstream may be explored to improve food security in climate-vulnerable Ethiopia, while the effects on downstream hydropower generation remain unknown. We focus on the tradeoff between upstream irrigation and downstream hydropower generation and the corresponding influences on the food-energy-water nexus with a coupled modeling framework - a multi-player microeconomic partial equilibrium (MME) food system model coupled with a water/crop model and a hydropower model.

2 - Advancing Science Through Multisector Dynamics Modeling Innovation

Chris R. Vernon, Pacific Northwest National Laboratory, Richland, WA, United States, chris.vernon@pnnl.gov, Casey D. Burleyson, Jennie S. Rice, Ian P. Kraucunas, W. Dave Millard, Jon Weers

The U.S. Department of Energy's Integrated Multi-sector, Multi-scale Modeling (IM3) project aims to improve understanding of the dynamics of human-Earth systems, including how different stressors might affect system vulnerability and resilience over multi-decadal time horizons. IM3 integrates previously autonomous, process-rich models from a range of sectors, such as energy, water, land, and population, with varying spatial and temporal resolutions. The IM3 Framework-Software-Data (FSD) team provides embedded guidance and develops standards and capabilities to help collaborators explore how different model configurations of varying complexity influence simulation fidelity.

3 - A 3-level Nested Decomposition Framework for Multi-year Power Systems Planning under Policy Uncertainty

Nestor Andres Sepulveda, Massachusetts Institute of Technology, Cambridge, MA, 02142, United States, nsep@mit.edu, Juan Pablo Vielma

This work develops a capacity expansion planning framework for power systems able to solve for the optimal investment strategy/pathway subject to uncertain policies such as CO2 limits and/or renewable energy mandates over several year into the future while accounting for detailed operation at an hourly resolution. The framework integrates Stochastic Dual Dynamic Integer Programming, Benders Partitioning and Dantzig-Wolfe decomposition in order to decouple and parallelize different levels and stages of the problem. The framework is implemented using the Julia general purpose programming language and its mathematical programming extension JuMP.

4 - The Role of Cross-border Energy Infrastructure in Resilience to Natural Gas Price Shocks in North America

Sauleh Ahmad Siddiqui, Johns Hopkins University, Baltimore, MD, 21218, United States, siddiqui@jhu.edu, Charalampos Avraam, Maxwell Brown

We investigate the role of cross-border infrastructure — natural gas pipelines and electricity transmission lines — on energy resilience in North America. We couple the North American Natural Gas Model (NANGAM); a partial-equilibrium model for natural gas production, transport, storage, consumption, and infrastructure; with the Regional Energy Deployment System (ReEDS 2.0); a high-fidelity, high-spatial resolution model that determines regional capacity expansion and dispatch for electricity; in order to understand the dynamics of this cross-border infrastructure development under different scenarios of shocks to natural gas supply.

■ TB85

S- Ravenna B

Finance, Portfolio Analysis

Contributed Session

Chair: Soobin Lee, Yonsei University, Yeonhui-ro, Seoul, 03716, Korea, Republic of

1 - The Effects of Portfolio Group Constraints in Estimation Risk

Luis Chavez-Bedoya, Universidad Esan, Lima, Peru, lchavezbedoya@esan.edu.pe, Francisco Rosales

Group constraints limit the fraction invested in certain subsets of assets and generate portfolios covering the spectrum between the 1/N portfolio and the optimal portfolio fully invested in risky assets. In this paper, under the expected loss function of Kan and Zhou (2007), we determine the impact on out-of-sample performance when group constraints are considered. The resulting optimal portfolio rule combines the risk-free asset with M+1 sample portfolios: M portfolios satisfying each of the group constraints and a zero-exposure portfolio. We show that adding group constraints , and individually estimating each of the portfolios, have an important impact in reducing estimation risk.

2 - Comparison Study of Portfolio Insurance Strategies: CPPI Versus VTPI

Olga Biedova, Bentley University, Waltham, MA, United States, obiedova@bentley.edu

We compare two portfolio insurance strategies: Constant Proportion Portfolio Insurance (CPPI) and Volatility Target Portfolio Insurance (VTPI), an option based portfolio insurance strategy with an embedded option linked to a Volatility Target portfolio. We rely on numerical simulations and use the main ideas of the stochastic dominance theory. The bootstrapping approach allows us to relax the assumptions on the risky asset price dynamics. We present an extended comparative quantitative analysis of strategy performances in various market scenarios and within a range of input parameter values.

3 - Evaluating the Investment Performance of the 1/N Portfolio Based on the Euclidean Distance

Soonbong Lee, Yonsei University, Seoul, Korea, Republic of, tnsqhd94@gmail.com, Hongseon Kim, Seongmoon Kim

This study newly illuminates the excellence of the 1/N portfolio through its Euclidean distance, a new portfolio evaluation measure based on the vector distance. First, this study proves that the 1/N portfolio's diversification strategy decreases the Euclidean distance's upper limit. Furthermore, we empirically compare the 1/N portfolio and five representative portfolio-selection models in terms of performance measures related with returns and the Euclidean distance. The results of the analysis lead to the conclusion that the 1/N portfolio can achieve investment performance as excellent as the other portfolio models' due to the superiority of its Euclidean distance.

4 - Comparative Analysis on Investment Performance According to the Accuracy in Market Forecast

Soobin Lee, Yonsei University, Seoul, Korea, Republic of, Hongseon Kim, Seongmoon Kim

In this paper, comparison of performance of the Optimal portfolio model by accuracy in prediction is presented. To do this, the accuracy of input variables for the Optimal portfolio is adjusted using the convex combination of in-sample and out-of-sample data. The performance of portfolio is evaluated by several criteria including Euclidean Distance from in-sample portfolio, which is considered as optimal standard portfolio in this paper. Through this study, we expect to show how much the performance of the optimal portfolio is affected by the accuracy control of the input variable.

5 - An Omega Model with Stochastic Dominance Efficiency Approach

Chen Chang, National Chi Nan University, Nantou, Taiwan, ccjeff85@hotmail.com, Jing-Rung Yu, Paul W. Chiou, Ming-Yi Huang

This study advances the Omega portfolio model by integrating a nonparametric method, the stochastic dominance efficiency approach. Though it grants flexibility by considering a return threshold set by investor, the Omega model tends to be over-optimistic and overweight the low price stocks of high variance in returns. This can lead to loss and uncertainty in the portfolio performance. By selecting the portfolio that stochastically dominates the benchmark, the proposed Omega model yield more stable performance. We provide the empirical results using the daily returns of two data sets, the Exchange Traded Funds and the S&P 500 composite stocks.

■ TB86

S- Ravenna C

Advanced Analytics for Manufacturing and Health

Emerging Topic: Advanced Manufacturing

Emerging Topic Session

Chair: Trung Le, North Dakota State University, Fargo, ND, 58102, United States

Co-Chair: Om Yadav, PhD, North Dakota State University, Fargo, ND, United States

1 - Deep Learning for Distortion Prediction of Additive Manufacturing

Linkan Bian, Mississippi State University, Industrial and Systems Engineering Department, Mississippi State University, MS, 39762, United States

Laser-Based Additive Manufacturing (LBAM) is a fabrication process that is a key aspect of Industry 4.0, which aims to employ many sensors for continuous process control. One current challenge in LBAM is the geometric inaccuracy of fabricated parts. To increase accuracy, accurate predictions of distortion are needed. Here we develop a novel Deep Learning approach that accurately predicts distortion well within LBAM tolerance limits by considering the local heat transfer for pointwise distortion prediction. Our Deep Learning approach not only gives highly accurate predictions but also fits into the Industry 4.0 framework of analyzing big data with manysensors.

2 - Validation Framework for Sleep Stage Scoring in Wearable Sleep Trackers and Monitors

Trung (Tim) Le, North Dakota State University, North Dakota State University, Fargo, ND, 58102, United States, trung.q.le@ndsu.edu

The increasing trend in transforming point-of-care sleep tracking devices to polysomnographic (PSG) alternatives has necessitated evaluation and validation frameworks. We proposed a quantitative evaluation framework to assess the performance of wearable sleep tracking devices relative to the PSG gold standard. The proposed framework compares sleep features epoch-by-epoch in all N1, N2, N3, REM and wake stages. The evaluation of sleep tracking devices with PSG included the wake-sleep analysis, sleep staging distribution comparisons, and localized analysis.

3 - Probabilistic Graphical Model of Acute Disorder Pathogenesis for Patient-specific Preventive Treatment

Phat K. Huynh, Doctoral Student, North Dakota State University, Fargo, ND, United States, phat.huynh@ndsu.edu

Disease pathogenesis has not been encoded in machine learning models because of its complex temporal dependencies and inter-patient stochastic variability. This paper proposes a pathogenesis probabilistic graphical model (PPGM) that incorporates pathogenetic domain knowledge to capture mechanisms leading to disease onsets. PPGM model consists of a static Bayesian network of patient attributes and a pathogenetic temporal model of pathogenetic dynamics. The PPGM model presents an inference paradigm for conditional patient queries and k-step onset forecasting. The model was evaluated by two case studies: Obstructive Sleep Apnea (OSA) and Paroxysmal Atrial fibrillation (PAF).

4 - Scheduling Medical Interpreters: A Data-driven Optimization Model

Abdulaziz Ahmed, Assistant Professor, University of Minnesota, Business Dept, Crookston, MN, 56716, United States, aahmed20@umn.edu

According to the American Community Survey (ACS), twenty-four million people in the United States are not able to speak English well or do not speak English at all. Offering interpreting service for patients who cannot speak English (limited English Proficiency patients (LEPPs)) in hospitals is mandatory according to Title VI of the Civil Rights Act of 1964. In addition, interpreting service significantly affects the quality of medical service. This research develops a data-driven optimization model for scheduling medical interpreters in medical centers. The model minimizes the total costs of full-time as well as part-time interpreters and maximizes interpreter performance rating.

5 - Nonparametric Moments Estimation for Li-ion Batteries Degradation Data

Hon Keung Tony Ng, Southern Methodist University, Department of Statistical Science, Dallas, TX, 75275-0332, United States, Lochana K. Palayangoda

In this paper, we propose the use of nonparametric empirical saddlepoint approximation to estimate the moments of the lifetime distribution based on degradation data. The major advantage of the proposed method is that it does not require the knowledge about the underlying random distribution of the degradation process. The performance of the proposed approach is compared to some existing parametric approaches for the prediction of end of performance of lithium-ion batteries by means of Monte Carlo simulation. A lithium-ion batteries degradation dataset from a lab experiment at different currents is used to illustrate the proposed method.

■ TB87

S- Madrona

Financial Risk and Regulation

Sponsored: Finance

Sponsored Session

Chair: Hamed Amini

1 - A Theory for Measures of Tail Risk

Fangda Liu, Assistant Professor, University of Waterloo, Waterloo, ON, Canada, Ruodu Wang

The notion of "tail risk" has been a crucial consideration in modern risk management and financial regulation. In this work, we carry out an axiomatic study for tail risk measures which quantify the tail risk. The two popular classes of regulatory risk measures in banking and insurance, the Value-at-Risk and the Expected Shortfall, are prominent, yet elementary, examples of tail risk measures. We establish a connection between a tail risk measure and a corresponding law-invariant risk measure, and investigate their joint properties. We explore relevant issues on tail risk measures, such as bounds, distortion risk measures, risk aggregation, and elicitability.

2 - Market-making Costs and Liquidity: Evidence from CDS Markets

Stathis Tompaidis, University of Texas-Austin, McCombs School of Business, IROM Department, Austin, TX, 78712-1179, United States, Stathis.Tompaidis@mccombs.utexas.edu, Mark Endel Paddrik

We provide a stylized model to study the implications of dealer costs on dealer behavior and market liquidity. In an empirical study of the single-name CDS market between 2010-2016, we find that transaction prices between dealers and clients have recently become more dependent on the inventories of individual dealers; that the volume with clients decreases, but that interdealer volume decreases much more; and that dealers with large inventories become more likely to trade with clients. Our results are consistent with the view that recent regulatory reforms increased the cost of holding inventory for dealers, and the cost of interdealer trading.

3 - Capital Regulation and Dynamic Financial Contagion

Zachary Feinstein, Stevens Institute of Technology, Hoboken, NJ, 63130, United States

In this talk we construct a continuous time model for price-mediated contagion precipitated by a common exogenous stress to the banking book of all firms in the financial system. In this setting, firms are constrained so as to satisfy a risk-weight based capital ratio requirement. We use this model to find analytical bounds on the risk-weights for assets as a function of the market liquidity. Under these appropriate risk-weights, we find existence and uniqueness for the joint system of firm behavior and the asset prices. Numerical case studies are provided to demonstrate various implications of this model.

4 - Cascading Losses in Reinsurance Networks

Ariah Klages-Mundt, Cornell University, Ithaca, NY, United States, aak228@cornell.edu, Andreea Minca

We develop a model for reinsurance cascades by which primary losses spread via general contracts, such as typical excess of loss (XL). We show that existing proportional contract models greatly underestimate risk. We characterize fixed points in our model and exotic cases of network structure that cause network effects to dominate overall payments. We develop efficient algorithms and apply them to data on real reinsurance networks. Our simulations demonstrate (1) extreme parameter sensitivity, which makes risk measurement difficult and incentivizes firms to cooperate to prevent fraud, and (2) nonlinearities from XL contracts obfuscate risks and can cause excess costs in a real network.

■ TB88

S- Cedar A

Health Care, Modeling and Optimization X

Contributed Session

Chair: Mandana Rezaeiahari, University of Arkansas for Medical Sciences, Fay W. Boozman College of Public Health 4301, Little Rock, AR, 72205, United States

1 - On the Solution of Scheduling Uninterruptible Services with Stochastic Duration: A Distributionally Robust Optimization Approach

Ana Celeste Batista, Research Intern, Skolkovo Institute of Science and Technology, Moscow, Russian Federation, abatista@uc.cl, David Pozo, Jorge Vera

We introduce a mixed integer optimization model for dealing with uninterruptible services with random duration, i.e., once the service is scheduled it should remain schedule until it is finished. The duration of the service is assumed to be stochastic. The underlying stochastic process service duration is ambiguous. Thus, we consider that known information is limited only to the first moment and the support of the true probability distribution. We present a distributionally robust optimization (DRO) framework for describing this problem. We present numerical simulations to study the admission planning problem assuming limited distributional information of the patient's stay duration.

2 - Planning and Scheduling Operating Room Using Modified Block Scheduling Strategy with Considering the Surgical Team and Post-operative Units Constraint

Motahareh Tavakolikashi, Student, Suny at Binghamton, Binghamton, NY, United States, Nasser Salmasi

Operating room is the most important facility in hospital since it causes about 33% of total costs and produce about 67% of total revenue. Managing operating room is complicated due to many resource constraints and conflicts. Managers are interested in decreasing the costs while increasing patient's satisfaction level. We proposed a novel two phases model for planning and scheduling operating rooms. In this model, several modified block scheduling strategies are implemented and anesthesiologist constraints and post-operative units constraints are considered. The result shows this new model can solve reasonable size problems in a reasonable time.

3 - The Impact of Competition on Hospital's Technology Adoption

Varun Gupta, Penn State Erie, The Behrend College, Erie, PA, United States, vxg15@psu.edu, Ozgun Caliskan Demirag, Xin (David) Ding

In this paper, we examine how competition in local hospital service area drives hospitals' decision to adopt technology using secondary data. Additionally, we develop a series of hypotheses based on game theory and test the hypotheses with the performance data in econometric models.

4 - Designing Master Surgical Schedules

M'Hallah Rym, Kuwait University, Kuwait, rymmha@yahoo.com

This paper designs a master surgical schedule (MSS) of a fixed planning horizon for a pediatric hospital. The MSS determines the specialty associated with each operating room session of the planning horizon with the objective of minimizing the expected waiting times of elective surgeries, guaranteeing access to the operating theatre for each specialty, and optimizing the use of downstream resources. Using the optimized MSS in lieu of the fixed grid currently used by the hospital increases the throughput of the operating theatre by as much as 10%.

5 - Identification of Disparities Associated with Maternal Morbidity in Arkansas: A Bayesian Network Analysis

Mandana Rezaeiahari, Assistant Professor, University of Arkansas for Medical Sciences, Little Rock, AR, United States, Clare C. Brown

Although women of every race and ethnicity are affected by maternal mortality, in Arkansas, maternal mortality among black mothers is more than 2.5 larger than among white mothers. In this study, risk factors that are most likely to contribute to the higher risk of morbidity among racial minorities are identified using Bayesian networks. The probability of conditional dependencies of demographic and clinical characteristics to the maternal morbidities will be learned using unsupervised machine learning algorithms. Based on the result of our predictive algorithms, proper interventions can be proposed to slow down or stop the target condition at an identified stage of pregnancy.

■ TB89

S- Cedar B

Mean Field Games and Large Stochastic Systems

Sponsored: Finance

Sponsored Session

Chair: Xin Guo

1 - Beyond Mean Field Limits: Large Sparse Networks of Interacting Processes

Daniel Lacker, Columbia University, New York, NY, United States, dl3133@columbia.edu

We study large systems of stochastic processes (particles), in discrete or continuous time, in which each particle is associated with a vertex in a graph and interacts only with its neighbors. It is known that when the graph is complete and the number of particles grows to infinity, the system is well-approximated by a nonlinear (McKean-Vlasov) process, which describes the behavior of one typical particle. For general graphs, however, the system is no longer exchangeable, and the mean field approximation fails. Nevertheless, for a broad class of locally tree-like graphs, we show that a single particle and its nearest neighbors are characterized by an autonomous evolution we call the "local dynamics."

2 - Hierarchical Preferential Attachment Models: Statistical Analysis and Applications

Wenpin Tang, UC Berkeley, Berkeley, CA, United States

In this talk I will discuss various preferential attachment models, including the Buckley-Osthus model and hierarchical PA models. The degrees of these graph models are known to be power-law distributed. I will focus on the statistical analysis of these models: the MLEs are shown to be consistent and asymptotically normal. The theoretical results are corroborated with simulations and real world data.

3 - Portfolio Diversification and Model Uncertainty: A Robust Dynamic Mean-variance Approach

Xiaoli Wei, University Paris Diderot, Paris, France, tyswxl@gmail.com

This paper is concerned with a dynamic multi-asset mean variance portfolio selection problem under model uncertainty. We develop a continuous time framework for ambiguity aversion about both expected return rates and correlation matrix of the assets, and their effects on portfolio diversification. We prove a separation principle, which allows us to reduce the determination of the optimal strategy to the parametric computation of the minimal risk premium. Our results provide a justification for under-diversification, as documented in empirical studies. Moreover, time-dependent ambiguity sets may explain why a under-diversification becomes a well-diversification over time and verse versa.

4 - MFGs for Partially Reversible Investment

Haoyang Cao, University of California, Berkeley, CA, 94709, United States, Xin Guo, Joon Seok Lee

This paper analyzes a class of MFGs with singular controls motivated from the partially reversible investment problem. It establishes the existence of the solution when controls are of bounded velocity, solves explicitly the game when controls are of nite variation, and presents sensitivity analysis to compare the single-player game with the MFG. Our analysis shows that MFGs, when appropriately formulated, can demonstrate genuine game eects even without heterogeneity among players and additional common noise.

■ TB90

S- Redwood A

Location Decisions for Alternative Fuel Vehicles

Sponsored: Location Analysis

Sponsored Session

Chair: Ismail Capar, Texas A&M University, College Station, TX, 77843-3367, United States and Bowling Green State University, Bowling Green, OH, 43403, United States

Co-Chair: Yudai Honma, The University of Tokyo, Tokyo, 153-8505, Japan

1 - Distance Distribution of Shortest Travel Route that Includes a Visit to a Facility on a Continuous Network

Ken-ichi Tanaka, Keio University, Yokohama, Japan, ken1tnk@ae.keio.ac.jp, Kazuki Tanno

We focus on a continuous network in which origin and destination of trips are continuously distributed along links of the network, and present a method to derive the distance distribution of trips that includes a visit to a facility on the way to destination. It is assumed that every traveler chooses a shortest route in visiting a facility that minimizes the sum of the distance from origin to a facility and the distance from the facility to destination. We apply the proposed method to an actual road network and evaluate accessibility to a facility.

2 - Spacing of Intersections in Hierarchical Road Networks with Inward, Outward, and Through Traffic

Masashi Miyagawa, University of Yamanashi, 4-4-37, Takeda, Kofu, 400-8510, Japan, mmiyagawa@yamanashi.ac.jp

This paper develops a continuous network model for examining the spacing of intersections that connect different levels of roads in a hierarchical network. An analytical expression for the total travel time is obtained for a grid road network with two road types: minor and major roads. The travel time is defined as the sum of the free travel time and the delay at intersections. The optimal pattern of intersections that minimizes the total travel time is then obtained. The result shows how the road length, the intersection delay, the travel speed, and the traffic composition affect the optimal intersection pattern.

3 - Drone Base Location Planning for Disaster Relief

Hozumi Morohosi, National Graduate Inst Policy Studies, Tokyo, Japan, morohosi@grips.ac.jp, Takehiro Furuta

In this work we study a location problem of drone bases for disaster relief in a large region. Despite its rapidly growing technology, a drone is still suffering from short flight time allowance. This causes us to need multiple drones to cover whole a large area, and transport them by means of mass transportation such as a truck. Suppose several potential hazard areas are scattered in a large region and each area assumes the number of drones necessary for the search, we consider a problem where to build drone bases and how many drones should be allocated to each base in terms of covering location problem.

4 - Evaluating Impact of Flow Refueling Objectives on Transportation Corridor Deployment

Ibrahim Capar, Bowling Green State University, Bowling Green, OH, 43403, United States, icapar@bgsu.edu, Ismail Capar, Sevgi Erdogan, Mohammad M. Nejad

We consider a decision maker who focuses on creating EV corridor to maximize the number of EV served. While flow refueling location model (FRLM) literature uses flow and vehicles miles traveled objectives, these objectives do not prioritize an EV corridor. In this research, we introduce two new objective functions to prioritize charging station deployment on an EV corridor. The first model maximizes the total flow on an EV corridor. The second model maximizes the weighted total flow where weight is based on the distance on the EV corridor. We test models on Maryland transportation network.

■ TB91

S- Redwood B

Stochastic Models & Machine Learning: Applications to Healthcare

Sponsored: Manufacturing & Service Oper. Mgmt/Healthcare Operations

Sponsored Session

Chair: Fernanda Bravo, UCLA Anderson School of Management, Los Angeles, CA, 90024, United States

Co-Chair: Yaron Shaposhnik, University of Rochester, Rochester, NY, 14627, United States

1 - Provider Schedules with No Shows

Vera Tilson, University of Rochester, Rochester, NY, 14627, United States, Vera.Tilson@simon.rochester.edu

We address the problem of scheduling patient appointments in a family medicine clinic. A significant barrier to a clinic's sustainability is under-utilization of the medical providers it employs. Practically all patient appointments are scheduled some time in advance (from an hour to months ahead), and under-utilization happens because some patients do not keep their appointments and do not provide sufficient notice for the clinic to reschedule another patient into the freed slot. Using a stylized simulation model we investigate an algorithm for appointment capacity release that increases provider utilization.

2 - Simple Rules for Predicting Congestion Risk in Queueing Systems: Application to ICUs

Yuting Yuan, Simon Business School, University of Rochester, Rochester, NY, United States, yuting.yuan@simon.rochester.edu, Fernanda Bravo, Cynthia Rudin, Yaron Shaposhnik

We study the problem of predicting congestion risk in service systems. We define "high-risk states" as system states that are likely to lead to a congested state in the near future, and strive to formulate simple rules for determining whether a given system state is high-risk. We show that for simple queueing systems, such as the $M/M/\infty$ queue with multiple customer classes, such rules could be approximated by linear and quadratic functions on the state space. For more general queueing systems, we develop a computational framework and demonstrate through extensive computational study its effectiveness. We also show that in many cases linear classifiers provide very accurate prediction rules.

3 - Sparse Flexible Design: A Machine Learning Approach

Timothy Chan, University of Toronto, Mechanical and Industrial Engineering, Toronto, ON, M5S 3G8, Canada, Benjamin Potter

For a general production network, state-of-the-art methods for constructing sparse flexible designs are heuristic in nature, typically computing a proxy for the quality of unseen designs and using that estimate in a greedy manner to modify a current design. In this talk, we develop two machine learning-based approaches to constructing sparse flexible designs that leverage a neural network to accurately and quickly predict the performance of large numbers of candidate designs. Using small benchmark instances and a large case study of the flexibility of linear accelerators that deliver radiation to treat cancer, we demonstrate that our approach meets or beats the state-of-the-art.

4 - An Integrated Learning and Optimization Approach to Reduce Cancellations in the Operating Room

Nadia Lahrichi, Polytechnique Montreal, Montreal, QC, H3C3A7, Canada, nadia.lahrichi@polymtl.ca, Arnaud Augustin, Philippe Jouvet, Andrea Lodi, Louis-Martin Rousseau

In this talk, we propose a novel approach to deal with the integration of the intensive care unit to the (long term) surgical case assignment problem. The approach is based on graphical model optimization that includes the probability of canceling cases at each state. We use the practical case of the teaching hospital Sainte-Justine (CHUSJ), in Montreal and show that prioritizing patients during this process only increases the quality of the schedule without decreasing the occupancy rate of the OR.

■ TB93

S- Grand Ballroom B

Time-Inconsistent Decision Problems

Sponsored: Finance

Sponsored Session

Chair: Nan Chen, Chinese University of Hong Kong, Shatin N T, Hong Kong

Co-Chair: Xuedong He, The Chinese University of Hong Kong, Shatin, Hong Kong

1 - Failure of Smooth Pasting Principle and Nonexistence of Equilibrium Stopping Rules under Time Inconsistency

Wei Wei, Waterloo University, Mathematics 3, Waterloo, ON, N2L 3G1, Canada, weiw1422@gmail.com, Xunyu Zhou, Ken Seng Tan

This paper considers a time-inconsistent stopping problem in which the inconsistency arises from non-constant time preference rates. We show that the smooth pasting principle may fail under time-inconsistency. We prove that the smooth pasting principle solves a time-inconsistent problem if and only if certain inequalities are satisfied. By a stopping model which is commonly used in real options approach, we show that the violation of these inequalities can happen even for very simple non-exponential discount functions. Moreover, we demonstrate that the stopping problem does not admit any intra-personal equilibrium whenever the smooth pasting principle fails.

2 - Forward Rank-dependent Performance Criteria: Time-consistent Investment under Probability Distortion

Moris Strub, The Chinese University of Hong Kong, Engineering Building, Hong Kong, NT, Hong Kong

We introduce forward rank-dependent performance processes and thereby extend the framework of forward criteria to include probability distortions. A fundamental challenge is how to reconcile the time-consistent nature of forward performance criteria with the time-inconsistency stemming from probability distortions. Our main results are an equivalence of definitions based on preservation of the performance value and time-consistency of policies, a full characterization of viable probability distortions by means of a bifurcation-type result and the introduction of an auxiliary, distorted financial market leading to a construction method for forward rank-dependent criteria.

3 - On the Strategies of Naive and Sophisticated Agents with Weighted Average Risk Preferences in Continuous Time

Sang Hu, The Chinese University of Hong Kong, Shenzhen, Shenzhen, 518172, China, husang@cuhk.edu.cn, Xuedong He

In the recent two papers by Ebert and Strack (2015, 2018), the authors show that under certain conditions, naïve agents never stop gambling while sophisticated agents never start to do so, when their risk preferences are characterized by cumulative prospect theory. In this paper, we investigate the strategies of the above-mentioned types of agents, whose risk preferences are induced by a weighted average of expected utility theory and cumulative prospect theory. Furthermore, we employ the definition of weak equilibrium to study the strategies of sophisticated agents. Our results then generalizes the ones by Ebert and Strack (2015, 2018).

4 - Non-Concave Utility Maximization without the Concavification Principle

Shuaijie Qian, National University of Singapore, Singapore, Singapore

The problems of non-concave utility maximization appear in many areas of finance and economics, such as in behavior economics, incentive schemes, aspiration utility, and goal-reaching problems. Existing literature solves these problems using the concavification principle. We provide a framework for solving non-concave utility maximization problems, where the concavification principle may not hold and the utility functions can be discontinuous. In particular, we find that adding bounded portfolio constraints, which makes the concavification principle invalid, can significantly affect economic insights in the existing literature. Theoretically, we give a new definition of viscosity solution and show that a monotone, stable, and consistent finite difference scheme converges to the solution of the utility maximization problem.

■ TB94

S- Grand Ballroom C

Kidney Allocation & Exchange

Sponsored: Health Applications

Sponsored Session

Chair: Joris Van de Klundert, Erasmus University-Rotterdam, Ridderkerk, 2983 HE, Netherlands

1 - Equitable Deceased Donor Kidney Allocation through Network Flows

Joris Van de Klundert, Professor, Mohammad bin Salman College, King Abdullah Economic City, 23964, Saudi Arabia, jklundert@mbsc.edu.sa

In the USA, the wait times for decease donor kidney transplants are long and inequitable. For instance, disparities exists between blood types and races. We analyze how transplant organs can be allocated (most) equitably, and characterize under which conditions equity can be achieved. The analysis is based on queuing theory and network flow formulations. The analysis will be illustrated using UNOS data, the results of which suggest concrete policy improvements.

2 - Maximum Matchings in Graphs for Allocating Kidney Paired Donation

Michal Mankowski, King Abdullah University of Science and Technology, Jeddah, Saudi Arabia, michal.mankowski@kaust.edu.sa, Sommer Gentry, Michael T.S., Dorry Segev

Kidney paired donation matches one patient and his incompatible donor with another patient and donor in the same situation for an organ exchange. Let patient-donor pairs be the vertices of an undirected graph G, with an edge connecting any two reciprocally compatible vertices. A matching in G is a feasible set of paired donations. We propose an edge-weighting of G which guarantees that every matching with maximum weight also has maximum cardinality, and also maximizes the number of transplants for an exceptional subset of recipients.

3 - A Centralized Allocation Mechanism for Public Housing

Weihua Zhang, University of British Columbia, Vancouver, BC, V5G 1Z2, Canada, weihua.zhang@sauder.ubc.ca, Yichuan Ding, Daniel Granot

In 2014, US programs of federal rental assistance helped nearly five million families. We model the affordable housing allocation problem as a centralized decision problem. The Housing Authority strives to accommodate move-in requests as well as requests of transfer between housing types. We assume that households list the housing types that they would accept without specifying their complete preference order. We further assume that the housing units of each type are homogeneous. For minimizing vacancy rate and maximizing portability (the responsiveness of the HA to households' accommodation requests), we formulate the problems as network flow problems and characterize the optimal solutions.

4 - Challenges in Match Offer Acceptance in the OPTN Kidney Paired Donation Pilot Program

Ruthanne Leishman, RN, MPH, UNOS, Seattle, WA, United States, Ruthanne.Leishman@unos.org

The OPTN KPD program offers hundreds of matches each year. Despite this, only about 45 transplants occur annually. A 92% match failure rate is the biggest challenge to achieving transplants. Hospitals refused 233/562 match offers from Jan17-Jun18. Another 257 matches failed due to a refusal in the same exchange. Donor related issues accounted for 39.9% of refusals, candidate issues 24.5%, HLA 26.6%, and other 26.1%. KPD data entered by hospitals screens donors and candidates for optimal matching, however, many refusals are behavioral. For example improperly entered unacceptable antigens (19.3%) or donor preferences (8.5%) and failure to remove candidates unavailable for transplant (22.3%).

5 - Scalable Robust Kidney Exchange

John P. Dickerson, Assistant Professor, University of Maryland, College Park, MD, United States, john@cs.umd.edu, Duncan McElfresh, Hoda Bidkhori

In barter exchanges, participants trade their endowed goods in a constrained economic setting without money. Transactions in barter exchanges are often facilitated via a central clearinghouse that must match participants even in the face of uncertainty—e.g., over participants, existence and quality of potential trades. Leveraging robust combinatorial optimization techniques, we address uncertainty in kidney exchange, a real-world barter market where patients swap (in)compatible donors. We provide two scalable robust methods to handle two distinct types of uncertainty in kidney exchange—over the quality and the existence of a potential match, along with preliminary experiment results.

■ TB95

S- Grand Ballroom D

Joint Session MIF/OPT: Stochastic Programming Methods and Applications

Sponsored: Minority Issues

Sponsored Session

Chair: Lewis Ntaimo, Texas A&M University, College Station, TX, 77843, United States

1 - Pathways Modeling and Scheduling for Connected Community Health under Uncertainty

Jiangyue Gong, Texas A&M University, College Station, TX, 77354, United States, gongjiangyue@gmail.com, Lewis Ntaimo

Pathways Modeling and Scheduling for Connected Community Health under Uncertainty Speaker: Jiangyue Gong [gongjiangyue@gmail.com] Co-Author: Lewis Ntaimo [ntaimo@tamu.edu] Affiliation: Texas A&M University, College Station, U.S.A

Pathways are structured and time-framed guidelines used by health-related services to detail essential steps of a process with a specific outcome. In this talk, we present a stochastic programming model for connected community health to schedule clients and resources for each step of the pathway under uncertainty in resource availability. The goal of the model is to optimize clients wait-time while providing workload balance among resources of the same type.

2 - Multistage Decision Making During Large-scale Wildfires

Brittany Segundo, Texas A&M University, College Station, TX, 77845, United States, brittany.segundo@tamu.edu, Lewis Ntaimo

Large-scale wildfires that have escaped initial containment efforts require a coordinated response from numerous agencies. While stochastic programming has been used to pre-position firefighting resources in advance of a fire season, we employ a multistage stochastic program to inform the allocation of resources during the course of a wildfire and its progression. Decision-makers face volatile fire growth and intensity as a result of uncertain weather changes, but previous response efforts also impact the fire progression. We approximate this multistage program with endogenous uncertainty using a rolling horizon approach.

3 - Risk-averse Multistage Stochastic Programs with Expected Conditional Risk Measures

Maryam Khatami, Texas A&M University, College Station, TX, 77840, United States, maryam.khatami@tamu.edu, Thuener Silva, Bernardo Kulnig Pagnoncelli, Lewis Ntaimo

We present a study of decomposition algorithms for risk-averse multistage stochastic programs with expected conditional risk measures (ECRMs). ECRMs are time-consistent, and we show that solving risk-averse problems in this case is as complex as solving risk-neutral ones. We consider ECRMs for both quantile and deviation mean-risk measures, deriving the Bellman equations in each case. We illustrate our results with extensive numerical computations for a hydrothermal scheduling and a portfolio selection problem.

4 - Stochastic Programing and Climate Data Analytics for Planning and Operating Distributed Generation Systems

Clara Novoa, Associate Professor, Texas State University, San Marcos, TX, 78666, United States, cn17@txstate.edu, Temitope Runsewe, Tongdan Jin

We present a non-linear model to find the optimal capacities and locations of wind turbines that minimize the lifecycle cost of a distributed generation system considering loss-of-load probability and thermal constraints. Volatilities on the wind turbines power generation are modeled through scenarios for the wind speed across the turbine blades. The cost of bringing energy from the grid and the income from selling back green energy are considered as recourse actions. Data analytics on wind speed for different cities permits to estimate the probability distribution for the power output. Sensitivity analysis reveals that the system has still affordable cost if fluctuations in the loads occur.

■ TB96

S- Willow A

Joint Session DEI/MIF: A Panel Discussion on the Role of the Professional Organization in Gender Harassment Mitigation

Emerging Topic: Diversity, Equity, and Inclusion

Emerging Topic Session

Chair: Julie Simmons Ivy, North Carolina State University, Raleigh, NC, 27695-7906, United States

Co-Chair: Christine Grant, North Carolina State University

1 - A Panel Discussion on the Role of the Professional Organization in Gender Harassment Mitigation

Julie Simmons Ivy, North Carolina State University, Raleigh, NC, 27695-7906, United States

There is an emerging national dialogue about aspects of diversity, equity and inclusion in STEM fields. The conduct of STEM colleagues in the workplace and at national conferences is a critical component of mitigating sexual and gender harassment. In this session, we will present (i) an overview of the National Academy of Engineering report on Gender Harassment, (ii) introduce the Societies Consortium on Sexual Harassment in STEMM (science, technology, engineering, mathematics and medicine) and (iii) review the INFORMS Meeting Code of Conduct Policy. This session opens the dialogue within INFORMS regarding sexual and gender harassment, the operationalization of code of conduct policies within professional organizations, and the role that organizations like INFORMS can play in creating safe spaces.

Panelists

- Christine Grant, North Carolina State University, Raleigh, NC, United States
- Michael P. Johnson, University of Massachusetts Boston, Department of Public Policy & Public Affairs, Boston, MA, 02125-3393, United States
- Shengfan Zhang, University of Arkansas, Department of Industrial Engineering, Fayetteville, AR, 72701, United States
- Katrina Sanford, Clinical Psychotherapist, Seattle, WA, United States

■ TB97

S- Willow B

Machine Learning in Finance

Sponsored: Data Mining

Sponsored Session

Chair: Gavin Feng

1 - Deep Learning in Asset Pricing

Markus Pelger, Stanford University, Stanford, CA, 94305, United States, mpelger@stanford.edu, Jason Zhu, Luyang Chen

We estimate a general non-linear asset pricing model with deep neural networks applied to all U.S. equity data and a substantial set of macroeconomic and firm-specific information. Our crucial innovation is the use of the no-arbitrage condition as part of the neural network algorithm. We estimate the stochastic discount factor that explains all asset prices from the conditional no-arbitrage moment constraints. Our model finds the key factors that drive asset prices, identifies mis-pricing of stocks and generates the mean-variance efficient portfolio. Our optimal portfolio has an annual out-of-sample Sharpe Ratio of 2.6.

2 - Risk Factors That Matter: Textual Analysis of Risk Disclosures for the Cross-Section of Returns

Alejandro Lopez-Lira, The Wharton School, University of Pennsylvania, Philadelphia, PA, United States, joselop@wharton.upenn.edu

Using unsupervised machine learning, I introduce interpretable and economically relevant risk factors that characterize the cross-section of returns better than the leading factor models, furthermore, I do not use any information from the past returns to select the risk factors. I exploit natural language processing techniques to identify from the firms' risk disclosures the types of risks that firms face, quantify how much each firm is exposed to each type of risk, and employ the firms' exposure to each type of risk to construct a 4-factor model. The risk factors roughly correspond to Technology and Innovation Risk, Demand Risk, Production Risk and International Risk.

3 - Smart Betas: A Machine Learning Perspective

Jianeng Xu, University of Chicago Booth School of Business, Chicago, IL, United States, Shentao Yang, Guanhao Feng, Nicholas Polson

Empirical studies in "smart beta" mostly focus on identifying stock winners via security sorting. In this paper, we study machine learning classification for "Beta v.s. Return" in the sorting perspective of Black, 1993. Classification conveniently takes multiple inputs (betas and firm characteristics) while sorting faces difficulty. In our comparative analysis, machine learning improves classification and annual performance. We identify the best methods (support vector machine and deep learning) and betas (net equity issues, asset growth, and operating profitability). Machine learning methods also tend to recommend similar stocks while security sorting portfolios are more diversified.

4 - A Machine Learning Approach to Estimating Large Positive Definite Covariance Matrix of High Frequency Data

Liyuan Cui, City University of Hong Kong, Hong Kong, Hong Kong, liyuan.cui@cityu.edu.hk

This paper proposes a novel covariance estimator via a machine learning approach. Our method simultaneously provides a consistent estimation in a one-step procedure. Moreover, in the presence of microstructure noises and asynchronous trading, the covariance estimator is guaranteed to be positive definite with the optimal rate of convergence. We provide a data-driven algorithm to select the optimal tuning parameters in practice. We apply the proposed estimator to vast portfolio allocations, which enjoy significantly enhanced out-of-sample portfolio risk and Sharpe ratios. The success of our approach helps justify the role that machine learning techniques play in finance.

Tuesday, 12:05PM - 1:35PM

■ TC01

CC- Room 201

Predictive Analytics in Healthcare

Sponsored: Data Mining

Sponsored Session

Chair: Zhang Qingpeng

1 - Predicting Depressive Disorders in the Elderly with Multitask Recurrent Neural Network

Qingpeng Zhang, City University of Hong Kong, Kowloon, 12180, Hong Kong, qingpeng.zhang@cityu.edu.hk, Zhongzhi Xu, Mingyang Li

This research aims to develop a state-of-the-art deep learning model for the individualized prediction of depressive disorders with a 22-year longitudinal survey data among elderly people in the United States. The experiments indicate that (a) machine learning models can provide an accurate prediction of the onset of depressive disorders for elderly individuals; (b) the temporal patterns of risk factors are associated with the onset of depressive disorders; and (c) the proposed multitask deep learning model exhibits superior performance as compared with baseline models.

2 - A Bayesian Non-parametric Approach to Modeling Multi-dimensional and Heterogeneous Disability Progression of Older Adults

Suiyao Chen, University of South Florida, Tampa, FL, 33617, United States, suiyaochen@mail.usf.edu, Hongdao Meng, Nan Kong, Kathryn Hyer, Mingyang Li

Predictive modeling of disability progression of older adults allows better understanding of their evolving needs on various healthcare settings (e.g., nursing home, hospital) and further development of more proactive preparedness decisions. Conventional modeling approaches often consider univariate disability progression with simplified modeling assumptions (e.g., homogenous population). This work proposes a Bayesian non-parametric approach to characterizing multi-dimensional and heterogeneous disability progression of older adults by relaxing the conventional modeling assumptions and further developing effective estimation algorithms.

3 - Temporal and Spatial Analysis of Mental Health on Social Media: Take U.S. as an Example

Jiaojiao Wang, The State Key Laboratory of Management and Control for Complex Systems, Institute of Automation, Chinese Academy of Sciences, Beijing, China, jiaojiao.wang@ia.ac.cn Jiaojiao Wang, Shenzhen Artificial Intelligence and Data Science Institute (Longhua), Shenzhen, China, jiaojiao.wang@ia.ac.cn, Junjie Lin, Qingpeng Zhang, Wenji Mao, Dajun Daniel Zeng

Geotweets data from May 11 to October 2 in 2014 on more than 60 hashtags related to mental health have been collected on Twitter social media platform. The correlation between the number of tweets and users related to mental health and deaths, sociodemographic indicators has been measured. Time series decomposition and forecasting method was applied to evaluate the seasonality, periodicity, trend of mental health related tweets. Temporal evolution and spatial analysis of the number of mental health related tweets and users on social media could help to implement novel digital public health surveillance methodologies for supporting policy makers in fighting the mental health epidemic.

4 - Hidden Markov Models for Sleep Identification via Commercial Wrist-worn Device

Kwok-Leung Tsui, City University of Hong Kong, City University of Hong Kong, Hong Kong, Jiaxing LIU, Yang Zhao

The use of wrist-worn devices to track and measure sleep cycle objectively grows increasingly popular. Existing algorithms for sleep/wake identification in these devices are mainly based on activity data inference and require expensive training or threshold setting.Our study proposed an unsupervised and personalized algorithm to infer sleep and wake states using both heart rates and step counts based on hidden Markov models. The proposed algorithm agreed mostly to Fitbit's scorings but enabled identifying more afternoon naps and earlier sleep onset in real-world case studies. Moreover, the estimated HMM parameters can reflect different behavior and circadian patterns among individuals.

5 - Parallel Computing for Large Scale Linear/Nonlinear Programming Based on Microservice Infrastructure

Jing He, Swinburne University of Technology, Victoria University, Hawthon, Australia

This talk will introduce a parallel algorithm and architecture to efficiently solve linear/nonlinear programming models with single-objective function and/or multiple-objective functions. The proposed Gradient Flow method for both single and multiple criteria programming will be implemented in a general distributed computing environment with the microservice infrastructure. The analytical performance of the proposed algorithm and the other well-known method, including the speedup upper bound and lower bound limits, will be derived. Numerical experiments and real-time applications will also be provided in order to verify the complexity of the proposed algorithm and architecture. The empirical results will demonstrate that the speedup of this parallel algorithm and architecture approaches linearity, which means that it can take full advantage of both the proposed algorithm and the distributed computing power as the size of the mathematical programming problem increases.

■ TC02

CC- Room 202

Efficient Learning and Optimization in Data Mining

Sponsored: Data Mining

Sponsored Session

Chair: Junzi Zhang

1 - A Continuous-time Perspective of Quasi-newton Methods

Honglin Yuan, PhD. Candidate, Stanford University, Stanford, CA, United States, Junzi Zhang, Stephen P. Boyd

In this work, we studied the continuous-time limit of Quasi-Newton methods.

2 - A Convex Optimization Approach to Radiation Treatment Planning with Dose Constraints

Anqi Fu, PhD Candidate, Stanford University, Stanford, CA, United States, anqif@stanford.edu, Baris Ungun, Lei Xing, Stephen P. Boyd

We present a method for handling dose-volume constraints as part of a convex programming framework for inverse treatment planning. Since these constraints are non-convex, we replace them with a convex restriction. To mitigate the restriction's impact on clinical objectives, we develop a two-pass planning algorithm that allows each dose-volume constraint to be met exactly on a second pass if its corresponding restriction is feasible on the first pass. In another variant, we add slack variables to prevent the problem from becoming infeasible when the user specifies an incompatible set of constraints. Finally, we introduce ConRad, a Python software package for convex radiation treatment planning.

3 - Ode Analysis of Stochastic Gradient Methods with Optimism and Anchoring for Minimax Problems and Gans

Ernest Kang Ryu, Assistant Adjunct Professor, University of California, Los Angeles, Los Angeles, CA, 90024, United States, eryu@math.ucla.edu, Kun Yuan, Wotao Yin

Despite empirical success, training dynamics of generative adversarial networks (GAN), which involves solving a minimax game using stochastic gradients, is still poorly understood. In this work, we analyze last-iterate convergence of simultaneous gradient descent (simGD) and its variants under the assumption convex-concavity. First, we show simGD, as is, converges with stochastic sub-gradients under strict convexity in the primal variable. Second, we generalize optimistic simGD to accommodate an optimism rate separate from the learning rate and show its convergence with full gradients. Finally, we present anchored simGD, a new method, and show convergence with stochastic subgradients.

4 - Distributional Robust Kelly Gambling

Qingyun Sun, PhD. Candidate, Stanford University, Department of Mathematics, Stanford, CA, United States, Stephen P. Boyd

In classic Kelly gambling, bets are chosen to maximize the expected log growth,under a known probability distribution.In this note weconsider the distributional robust version of the Kelly gambling problem, in which the probability distribution is not known, but lies in a given set of possible distributions.The bet is chosen to maximize the worst-case (smallest) log growth among the distributions in the given set.This distributional robust Kelly gambling problem is convex, but in general need not be tractable. We show that it can be tractably solved in the case of a finite number of outcomes,and some useful sets of distributions.

5 - Calibrating Multivariate L\'evy Processes with Neural Networks

Kailai Xu, PhD Candidate, Stanford University, Stanford, CA, 94305, United States, kailaix@stanford.edu, Eric Darve

Calibrating a L\'evy process requires characterizing its jump distribution. Traditionally this problem has been solved with nonparametric estimation using the empirical characteristic functions (ECF). For multivariate L\'evy processes and less smooth L\'evy densities, the problem becomes challenging as ECFs decay slowly and have large uncertainty because of limited observations. We solve this problem by approximating the L\'evy density with a parametrized functional form; the characteristic function is then estimated using numerical integration. In our benchmarks, we used deep neural networks and found that they are robust and can capture sharp transitions in the L\'evy density.

■ TC03

CC- Room 203

Data Mining in Healthcare

Sponsored: Data Mining

Sponsored Session

Chair: Mohamed A. Abdelhamid, PhD, California State University, Long Beach, CA, United States

1 - The Role of School-Based Programs in Minimizing Health-Compromising Behaviors: An Optimization Approach

Banafsheh Behzad, Assistant Professor, California State University, MS 8506, Long Beach, CA, 91101, United States, banafsheh.behzad@csulb.edu, Niloofar Bavarian, Sheena Cruz

School health programs are united by their desire to promote health and health-related outcomes amongst youth. They are also united by the fact that their success is contingent on successful program implementation, which is often impeded by a multitude of real-world barriers. We present a detailed example of the first known application of Linear Programming to Positive Action (PA). Our findings from this exploratory study support the utility of applying LP during the program planning and implementation processes of school health programs.

2 - Predicting Risk of Opioid Use Disorder by Leveraging Massachusetts All Payer Claim Data

Muhammad Noor-E-Alam, Northeastern University, Boston, MA, United States, md.alam@northeastern.edu

Given the magnitude of ongoing opioid crisis across the US, we utilized Massachusetts All Payer Claims Data (MA APCD) to assess the long-term opioid usage pattern of opioid-naïve patients and reveal the underlying risk factors that lead such a naïve patient towards Opioid Use Disorder. Outcome of this research is anticipated to combat the opioid addiction epidemic by ensuring judicious use of prescription opioids for patients who genuinely require them.

3 - Identifying Potential Cancer Victims on Twitter through Text Mining

Anton Ivanov, PhD, University of Illinois at Urbana–Champaign, Champaign, IL, United States

Health surveillance data often lacks temporal and spatial precision. Social media may offer new inexpensive and effective solutions that can complement current surveillance practices. Using the theoretical foundation related to language exhibited by those afflicted by cancer, we train a neural network capable of identifying language cues that are similar to those used by self-identified cancer patients. We use a multisource dataset that includes community characteristics, cancer registries, and text data from Twitter. We benchmark performance of several algorithms. Our testing indicated 88% accuracy, and predicted scores showed a moderate (.53) correlation with observed incidence rates.

4 - Health Misinformation: Role of Influential Users and Network Configuration in Online Health Communities

Srikanth Venkatesan, Assistant Professor, Cal Poly Pomona, Pomona, CA, United States, svenkatesan@cpp.edu

Please check the mobile app for this abstract.

■ TC04

CC- Room 204

Data-driven Strategic Decision Making

Sponsored: Data Mining

Sponsored Session

Chair: Xuehua Liao

1 - How Vivid Explanation Impacts User Trust on Explainable Artificial Intelligence

Xiaocong Cui, Georgia State University, Atlanta, GA, United States, xcui4@gsu.edu

AI has revealed remarkable predictive capabilities in many domains. However, how human interpret and evaluate the AI solutions have been lack of research. By drawing on research from the explanation literature, we find explanation presentation form and individual characteristics are two factors that influence user's perceived explanation quality. Specifically, we investigate how explanation with vividness impact user's perception on AI. Furthermore, we infer that individual characteristics can moderate the relationship between information vividness and trust. We will conduct an online experiment to verify our research model.

2 - Marketing Strategy from Customer Review Mining

Yi Lin, University of Miami, Coral Gables, FL, United States, lucky_plus1@163.com, Rame Tang

More and more companies do marketing strategic decision by means of online customer review data mining. In this research we will go into the question how firms benefit from onlinr customer review mining. We will focus mainly on the working mechanism of customers behaviors online on their purchase decision.

3 - The Value of Two-sided Platform Innovations

Shaoling Katee Zhang, University of North Carolina Wilmington, Wilmington, NC, United States, Tanya Tang

Two-sided platform innovation is a significant driver to platform sustainability. Yet how a two-sided platform innovates remains virtually unexplored in literature. Drawing on the principle of platform design, this study classifies two-sided platform innovations around the core interaction enabled by the platform, including innovation in participants, innovation in value unit, and innovation in interaction process (i.e., filter, match, facilitate, and curate). This study links these innovations to platform sustainability and examines how their impact changes across a platform's lifecycle stages.

4 - Effect of Consumers' Online Community Participation Sentiments on Purchase Behaviors: From the Perspective of Peer Influence

Xuehua Liao, School of Economics and Management of Fuzhou University, Fuzhou, 510275, China, liaoxueh@mail2.sysu.edu.cn, Jinghua Xiao, Kang Xie, Changbao Lu

There are some mixed findings of the rescent research on the effect of consumers' online community participation on purchase behaviors. And most of them are taken from perspectives of information research, information processing, perception of affiliation and customer satisfaction. This research deliberates the mixed findings from the perspective of peer influence. In-depth discussions will be taken on the basis of differentiating peer types and sentiment bias types by means of data mining. Furthur, different time distance of future purchase behaviors will be taken into account. Construal level theory will be used to interpret the results.

■ TC05

CC- Room 205

Practical Data Science with Applications in Industry

Sponsored: Data Mining

Sponsored Session

Chair: Raquel Ferreira

1 - Debugging Natural Language Models

Marco Tulio Ribeiro, PhD, Microsoft Research, Seattle, WA, United States

Machine learning models for NLP often exhibit puzzling bugs, such as making different predictions for input instances that are semantically equivalent or making logically inconsistent predictions. While such behaviors are very hard to find manually, I will present two different techniques for discovering these bugs automatically in any black box model. I'll present user studies to validate that what is discovered with these techniques really are bugs, and to compare the automated techniques with human experts trying to debug on their own. Finally, for both techniques, a simple data augmentation procedure mitigates the bugs with little or no discernible impact in accuracy.

2 - A Glimpse into the Role of Data Science in Google's Healthcare Efforts

Valeria Espinosa, Google, Mountain View, CA, United States

We'll discuss a few examples of health care related projects that data scientist at Google work on.

3 - Modeling of Language, Social, and Behavioral Abstractions for Microblog Political Discourse Classification

Kristen Johnson, Purdue University, IN, United States

Social media microblogs, specifically Twitter, allow politicians to communicate with the public as events unfold and shape public discourse on various issues. By selectively using framing techniques and political slogans, politicians are able to express or conceal their stances, as well as their underlying political ideologies and moral views on policies and issues. In this talk, I will present my approach for identifying and modeling adaptable abstractions of language and behavior which can handle the ambiguous and context-independent nature of political tweets, for the prediction and classification of ideological stances, policy frames, and moral foundations present in tweets.

4 - Generalized Predictive Comparisons for Interpreting Complex Models

Marcos O. Prates, UFMG, Belo Horizonte, Brazil

Machine learning algorithms, in general, offers a class of models that are a black boxes on the capacity to understand and interpret the insights and patterns discovered. This issue can be crucial in many scenarios, as interpretability helps not only in the better understanding and in the gain of knowledge to improve processes but also in the verification of model's correctness and adequacy. We propose a methodology to interpret multiple inputs and interesting functional forms of them to learn and interpret patterns that are inferred by complex models. We demonstrate the broad scope and significance of our methodology by case studies that utilize complex models such as BART, and neural networks.

5 - Statistical and Data Envelopment Analysis of Banks Operating in India

Badri Toppur, Rajalakshmi School of Business, Kuthambakkam Post, Chennai, 600124, India, badri.toppur@rsb.edu.in

We have compared the cost efficiency and operational efficiency of nationalized banks with those of private sector banks. The pool consists of 21 public sector banks, and 21 private banks. The analysis used is Statistical analysis and Data Envelopment Analysis, on the most recent data available (for financial year 2018) with the regulatory bank - Reserve Bank of India. The DEA reports and graphs have been obtained using Frontier Analyst software.

■ TC06

CC- Room 209

Machine Learning for Advanced Manufacturing

Sponsored: Data Mining

Sponsored Session

Chair: Arman Sabbaghi

1 - Machine Learning and Internal Audio Spectrogram Based Data Analytics for Advanced Manufacturing

Martin Byung-Guk Jun, PhD, Purdue University, West Lafayette, IN, 47907, United States, mbgjun@purdue.edu, Huitaek Yun, Hanjun Kim

This paper uses audio spectrogram and autoencoder-based machine leanring algorithm as an alternative sensing method to detect anomaly situations for manufacturing equipment. An industrial robot is used to test the method. The audio signals of a 6-axis industrial robot arm were collected. Then, spectrograms are used and then analyzed by applying Autoencoder architecture to discriminate anomalous status. To simulate normal and anomaly status, different load conditions were assigned on the robot end-effector. Two audio sensors were attached on the wrist and the base of the robot. After training, the features both from normal and anomalous status signals were tested based on reconstruction errors.

2 - Calibration of Multiple Physics-based Simulation Models with Unobservable Variables

Alaa Elwany, Associate Professor, Texas A&M University, College Station, TX, 77843, United States, elwany@tamu.edu

Physics-based modeling and simulation have been identified as high priority needs in metal additive manufacturing. Statistical calibration of these computer models using physical observations is a vital task without which one cannot confidently rely on the simulation model predictions. We address an important problem for the case when multiple physics-based simulation models are integrated, but experimental observations needed for calibration is not available for every model. We employ Bayesian networks to capture the relationship between the multiple simulation models and present a framework based on tuning variables to account for lack-of-data for the models with unobservable output.

3 - Efficient Prediction of High-fidelity Simulation Results Based on Low-fidelity Simulation in Additive Manufacturing

Lening Wang, Virginia Tech, Blacksburg, VA, 24061, United States, Xiaoyu Chen, SungKu Kang, Xinwei Deng, Ran Jin

Finite element analysis (FEA) has been widely adopted to model the thermal-field in additive manufacturing (AM) to validate the design and provide engineering insights. However, a high-fidelity FEA is usually time-consuming and cannot be readily approximated by a low-fidelity FEA due to a large disagreement. Reducing this disagreement merely based on low-fidelity FEA can significantly reduce the huge computation intensity introduced by high-fidelity FEA. This research proposes an efficient data-driven model to predict high-fidelity FEA results based on a low-fidelity FEA with satisfactory accuracy. A case study in three fused deposition modeling processes validates the proposed model.

4 - Distortion Model Transfer Between Materials in Laser Based Additive Manufacturing Systems via Bayesian Neural Networks

Arman Sabbaghi, Assistant Professor of Statistics, Purdue University, West Lafayette, IN, 47907, United States, sabbaghi@purdue.edu, Jack Francis, Ravi Shankar, Morteza Ghasri-Khouzani, Linkan Bian

Distortion in laser-based additive manufacturing (AM) systems is a critical quality control issue that is known to be material-dependent. One key challenge in AM systems is learning distortion models for new materials given past experiments on distinct materials. We present a Bayesian neural network methodology to transfer distortion models across different materials in an AM system, thereby leveraging past experiments to learn distortion models for new materials. We demonstrate the utility of this method with case studies on disks additively manufactured using Ti-6Al-4V and 316L stainless steel.

■ TC07

CC- Room 210

Innovative Machine Learning Techniques in Transportation

Sponsored: Data Mining

Sponsored Session

Chair: Amirmahdi Tafreshian

1 - A Deep Learning Application for Traffic Condition Estimations by Utilizing Data from Connected and Autonomous Vehicles

Daisik Nam, University of California, Irvine, Irvine, CA, 92617, United States, daisikn@uci.edu, Riju Lavanya, Jayakrishnan R., Inchul Yang, Woo Hoon Jeon

This paper develops techniques and algorithms to estimate various traffic indices for continuous flow by applying machine learning methodologies to data collected from Connected and Autonomous Probes. We propose a new model that considers the correlation of temporal traffic patterns between links in a network. The design attributes of the proposed algorithm make it suitable for accepting input data from multiple sensors on multiple links. Numerical experiments indicate that the proposed model can better estimate traffic condition than a model based on Edie's definition.

2 - Integrating Autonomy into Urban Systems

Cathy Wu, MIT, Cambridge, MA, United States

Self-driving cars are not expected to reach full adoption for at least another 35 years. In the meantime, how will self-driving cars change urban mobility? Leveraging and advancing techniques in model-free deep reinforcement learning and control theory, the talk explores and quantifies the potential impact of a small fraction of automated vehicles on low-level traffic flow dynamics such as congestion on a variety of important traffic contexts. Together, these optimization methods and empirical findings demonstrate how small changes in vehicles, sensors, and infrastructure can be harnessed for significant impact on urban mobility, and shed light into the future study of mixed autonomy systems.

3 - An Efficient Learning-based Network Contraction Approach for Optimal Path Finding Problem in Dynamic Stochastic Networks

Fatemeh Fakhrmoosavi, Michigan State University, East Lansing, MI, United States, moosavi@egr.msu.edu, Ali Zockaie, Khaled Abdelghany, Hossein Hashemi

The study aims to develop a network contraction approach to reduce the network size of each specific origin and destination (OD) pair in stochastic time-dependent networks. The network contraction is based on the comparison of optimistic and pessimistic solutions resulting from minimum and maximum travel time realizations of a Monte-Carlo simulation-based (MCS) approach. In this respect, the researchers propose a learning approach to utilize the information of the realizations in the initial iterations of the MCS approach. Implementation of this approach is in place for two real-world large-scale applications with significant computational improvements and an acceptable accuracy level.

4 - A Balanced Trip-based Graph Partitioning Algorithm for Dynamic Peer-to-peer Ridesharing

Amirmahdi Tafreshian, University of Michigan, Ann Arbor, MI, 48109, United States, atafresh@umich.edu, Neda Masoud

Ridesharing systems connect drivers who use their personal vehicles to travel with riders who are in need of transportation. Since each driver/rider may have several potential matches, the rideshare operator needs to make the matching decision based on a global view of the system that includes all active riders and drivers. However, the underlying ride-matching problem can become computationally expensive, when such systems operate over a large region. This research proposes a partitioning algorithm to decompose the matching problem into multiple subproblems with the goal of reducing the overall computational complexity of the problem while providing high-quality solutions in real time.

5 - Identfying Failure Reasons in Aviation Operations with Machine Learning

Burak Cankaya, Embry Riddle Aeronautical University, Daytona Beach, FL, 43235, United States

Aviation failures have the greatest impact of all transportation modes because of the vital role and economic impact. In this reseach we utilise multiple Machine Learning Algorithms to find the root causes of Aviation failures from public databases.

6 - Strategic Fleet and Crew Planning Business Applications

Aaron Glassman, Embry-Riddle Aeronautical University, Daytona Beach, FL, United States

Airline travel is growing over the time over the world. Airline operators keep growing to serve to the demand by passengers. One of the main parameters that define the size of the company are the number of aircrafts and the number of pilots working for the company. Training a pilot is one of the most time consuming type of professions. Pilots are currently in high demand and airline operators have hardships to optimize the number of pilots they have for their different fleets. It is even harder for companies to plan their future fleet and align their internal and external pilot trainings to meet the future pilotage need. In this study a mathematical model will be developed to optimally plan the future aircraft need for a commercial airline and plan the pilot training to serve to today's pilot need and future pilot needs. The research problem is very common for many commercial airlines because of the competitive demand for pilots and time consuming nature of future fleet planning and aircraft delivery and the mathematical model will serve to solve the actual need and theoretical baseline for government and private aviation industries.

■ TC08

CC- Room 211

AI/ML Novel Applications

Emerging Topic: Artificial Intelligence & Machine Learning

Emerging Topic Session

Chair: Sebastian Souyris

1 - Image-based Sales Forecasting for Fast-fashion Industry

Recep Yusuf Bekci, McGill University, Montréal, QC, Canada, Mehmet Gumus

In fashion industry, the image is the key motive of the preferences of customers. Our intention in this study is to leverage product images and come up with more accurate forecasts and assortments. We utilized computer vision techniques, more specifically, convolutional neural networks for retrieving the information from images and deep learning and other machine learning methods for predictions. We used e-commerce data from one of the largest Fast-Fashion retail companies in Eastern Europe.

2 - Machine Learning to Predict Audience and Schedule Shows in Television

Jaime Miranda, Universidad de Chile, Diagonal Paraguay, Santiago, 8330015, Chile, jmirandap@fen.uchile.cl, Sebastian Souyris

We predict audience television and schedule shows using ML and Integer Programming methods. Our algorithms are used by leading US networks. We present how the prediction and scheduling connect to maximize revenue.

3 - AI and Large Scale Dynamic Discrete Choice Models

Sebastian Souyris, The University of Texas at Austin, Austin, TX, 10028, United States, sebastian.souyris@utexas.com

The estimation of Dynamic Discrete Choice Models is typically very time consuming. We discuss methods to alleviate the computational burden with AI.

■ TC09

CC- Room 212

Methods and Models for Big Network Data Problems

Sponsored: Artificial Intelligence

Sponsored Session

Chair: Bin Zhang, University of Arizona, Tucson, AZ, 85721, United States

1 - Would Users Post More? A Hidden Markov Model of Reviewer Learning Dynamics in User-generated Content Platform

Zheng Fang, Purdue University, West Lafayette, IN, United States, Jinyang Zheng, Karthik Kannan, Guopeng Yin

Review-in-review (RIR) is a function that information technology companies apply to collect users' valuation of the generated content. Users could click "helpful", "unhelpful" button or write "review" in the form of text to the content they read. It makes RIR a method for users to express their opinion and to measure the quality of content before they read. The introduction of RIR would reshape the content generating process since users' participation in the platform would be influenced by the RIR of other users. To evaluate the effectiveness of our idea, we root our research in the context of a movie review platform. In this study, we implement the Hidden Markov Model (HMM) to capture the learning dynamics of users based on their unobserved learning patterns. We estimate the learning state of users on a daily basis and it shows significant evidence that RIR would influence users' content generating process.

2 - Prescriber and Pharmacy-Sharing Effect on Prescription Opioid Abuse: A Large-Scale Social Network Analysis

Yongcheng Zhan, University of Arizona, Tucson, AZ, 85719, United States, Bin Zhang

The misuse of and addiction to opioids is a serious national crisis that affects public health as well as social and economic welfare. The state-run prescription drug monitoring programs (PDMPs) play an important role in opioid misuse identification and prevention. We innovatively used social network analysis techniques to study PDMP data in Arizona and found there existed a statistically significant network autocorrelation effect on patients' opioid high-dose status. We found some of the prescribers were systematically more easily to prescribe opioid to patients. The identification of these prescribers with potential risky prescribing behavior may improve patient and drug safety.

3 - Predicting Cryptocurrency Movement: Analysis of Blockchain Transaction Graph

Yuxin Zhang, University of Texas at Austin, Austin, TX, United States, yuxin.zhang@utexas.edu, Rajiv Garg, Patrick L. Brockett, Linda Golden

We propose an iterative learning model to predict the evolution of blockchain transactions based on its entire transaction history. We develop various patterns of transaction subgraphs and use those to predict volume and amounts of transaction graphs in future blocks. We further develop the insights to predict the exchange rate for the cryptocurrency using the identified transaction subgraphs. Additionally, we provide discussion on how framework is valuable in understanding anomalies in blockchain enabled supply chain.

4 - Time-space Network Model and Solution Algorithm for a Variety of Vehicle Routing Problem with Backhauls

Daiki Saito, Waseda University, Tokyo, Japan, Takashi Hasuike

Multi-Trip Split-Service Vehicle Routing Problem with Backhauls is investigated in this study. This variant of the MT-VRPB allows two or more vehicles to serve a single customer with its linehaul or backhaul order. The problem is modelled on a Time-Space Network, and solved with a heuristic approach involving general-purpose numerical solver.

5 - A Network's Gender Composition and Communication Pattern Predict Women's Leadership Success

Yang Yang, Research Assistant Professor, Kellogg School of Management, Evanston, IL, United States, yang.yang@kellogg.northwestern.edu, Nitesh V. Chawla, Uzzi Brian

We use social network information drawn from 4.5 million email correspondences among hundreds of students who were placed directly into leadership positions to understand the link between graduate school social networks and placement into leadership. Using a quasi-experiment and IV2SLS regression, we find that for men, the higher centrality in the network, the higher his leadership placement will be. While centrality also predicts women's placement, high-placing women have a distinctive inner circle of women. Women whose networks resemble those of high-placing men are low-placing, despite having leadership qualifications comparable to high-placing women.

■ TC10

CC- Room 213

Joint Session SMA/Practice Curated: Optimization Methods in Social Media Analytics

Sponsored: Social Media Analytics

Sponsored Session

Chair: Theodore T Allen, Ohio State University, Columbus, OH, 43210-1271, United States

1 - Mapping Educational Effects from Public Service YouTube Advertising

Theodore T. Allen, Ohio State University, Columbus, OH, 43210-1271, United States, allen.515@osu.edu, Tengmu Hu

Working with an educational nonprofit called factSpread, we study the effects of advertising on YouTube with visual displays mapping topic selection, sentiment, and key word dispersion across the USA Obama-Trump counties in swing states. Levels are divided by statistical confidence. The levels of knowledge are compared before and after interventions as well as viewership.

2 - The Good, the Bad, and the Social Media: Financial Implications of Social Media Reactions to Firm-Related News

Julie Zhang, University of Massachusetts-Lowell, Lowell, MA, 01854, United States

We study the relationship between press news, user generated content, enterprise generated content, and firm performance. Employing data from press news articles, financial information, twitter posts of firms and microbloggers, we examine whether social media content reduces information asymmetry and provide additional information value to the public on news event days. Our analysis reveals several interesting findings. We find an interplay between press news articles, firm tweets, and user tweets; where firms are more active on social media and tweet more often when positive news is released on the firms than negative news.

3 - Social Media Optimization Using Deep Reinforcement Learning

Michel Ballings, University of Tennessee, Knoxville, TN, 37996, United States, Brandon Bell, Senne Van Steelandt

The goal of this study is to find an optimal social media policy. At any point in time the system recommends the next best social media action based on an online deep learning system. We devise and compare custom reward signals, and different architectures. Our system takes into account a large number of variables, including shares, likes, number of comments, content of comments, posted images, posted videos, and posted text.

4 - Acquisition Modeling in the Nonprofit Sector Based on Facebook Data

Lisa Schetgen, Ghent University, Belgium, lisa.schetgen@ugent.be, Matthias Bogaert, Matthijs Meire, Dirk Van den Poel

This research investigates whether Facebook data can be used to predict donation behavior. On the basis of individual specific Facebook data (i.e. Facebook groups, pages, and page categories), we build an acquisition model that predicts an individual's likelihood to become a donor. Three different classification algorithms are being compared, namely Bagging, Random Forest and Adaboost. Furthermore, by constructing different models, we assess the value of different Facebook features as predictors of donation behavior.

■ TC11

CC- Room 214

Centralized and Decentralized Control of Queueing Systems

Sponsored: Applied Probability

Sponsored Session

Chair: Philipp Afeche, University of Toronto, Toronto, ON, M5S 3E6, Canada

1 - Control of Queueing Systems with Distorted Customer Types

Dongyuan Zhan, University College London, School of Management, Gower Street, London, WC1E 6BT, United Kingdom, d.zhan@ucl.ac.uk, Arturo Estrada, Rouba Ibrahim

We study queueing systems where customers may distort their true types to shorten their waiting. For example, such systems arise in healthcare settings where patients exaggerate their own symptoms in order to be seen faster, or with public housing applications where applicants may lie on their applications to jump the queue. We investigate optimal joint inspection and routing policies in such a setting. An inspection reveals some additional information about the true types of the customer, but is costly to the inspector, and a routing policy classifies customers according to different priority levels, thus resulting in different, priority-dependent, waiting times.

2 - Dynamic Matching and Centralized Relocation in Ridesharing Platforms

Nasser Barjesteh, University of Chicago, Chicago, IL, 60615, United States, barjesteh@chicagobooth.edu, Baris Ata, Sunil Kumar

This paper studies dynamic controls in ridesharing platforms. We focus on the dynamic matching of customers and driver and centralized relocation of drivers from one area to another. We model the ridesharing system as closed stochastic processing network. We focus on the heavy traffic analysis of the network and obtain a limiting singular control problem. We solve this control problem numerically and interpret it as a pre-limit policy for the ridesharing system.

3 - Pricing, Service Design and Contracting for On-demand Public Transit

Ankur Mani, University of Minnesota, MInneapolis, MN, 63108-2432, United States, amani@umn.edu, Philipp Afeche, Sherwin Doroudi, Varun Gupta, Daniel F. Silva, Alexander Vinel

Municipalities worldwide are looking to improve the service-quality/cost trade-off for public transit by adding on-demand options to fixed-route/fixed-schedule services. Cities typically contract on-demand service operations to third-party providers. This raises the following question that we explore in this talk: How to tailor pricing, service design, and contracting decisions to a city's demand characteristics, operating objectives and constraints?

4 - Ride-hailing Networks with Strategic Drivers: The Impact of Platform Control Capabilities on Performance

Zhe Liu, Imperial College London, London, 10027, United Kingdom, Philipp Afeche, Costis Maglaras

We study the performance impact of two operational controls, demand-side admission control and supply-side repositioning control, in ride-hailing networks with strategic drivers. We characterize the system equilibria for various control regimes, show how the performance gains from these controls depend on the capacity and the network demand imbalance, and provide new results on how admission control affects drivers' repositioning decisions.

■ TC12

CC- Room 2A

Joint Session APS/I-Sim: Advances in Simulation and Stochastic Optimization

Sponsored: Applied Probability

Sponsored Session

Chair: Henry Lam, Columbia University, New York, NY, 10027, United States

1 - Central Limit Theorems for Variance-Reduced First-Order Schemes

Uday Shanbhag, Penn. State, State College, PA, United States, udaybag@psu.edu, Jinlong Lei

We consider variance reduced stochastic gradient, accelerated gradient, and momentum methods for strongly convex stochastic programs. Under suitable assumptions on batch-sizes, we establish CLTs for each scheme. In addition, we provide an avenue for constructing confidence regions for the optimal solution .(joint work with Jinlong Lei).

2 - A New Family of Output Sensitivity Measures

Wendy X. Jiang, Northwestern University, Evanston, IL, United States, XiJiang2020@u.northwestern.edu, Barry L. Nelson, Jeff Hong

How sensitive is your simulation output to your simulation input models? Even constructing a rigorous formulation of this question is not easy. In this talk we propose a new family of output-with-respect-to-input sensitivity measures and identify two particularly useful members of it. A further benefit of this family is that there is a simple estimator of any member of the family with no additional simulation effort beyond the nominal experiment. Numerical examples are provided.

3 - A Monte Carlo Algorithm for Solving Perron-Frobenius Eigenvalue Problems

Peter W. Glynn, Stanford University, Stanford University, Stanford, CA, 94305-4026, United States

We discuss the use of sampling-based methods that exploit regenerative representations for the Perron-Frobenius eigenvalue, eigenfunction, and eigenmeasure for an irreducible non-negative operator. We discuss the central limit theory for these estimators, and their implications for rates of convergence and construction of confidence intervals. This work is joint with Paritosh Desai.

4 - Optima Transport Relaxations

Saied Mahdian, Stanford University, Stanford, CA, 94305, United States, smehdian@stanford.edu, Jose Blanchet, Peter W. Glynn

We propose a class of relaxations for the optimal mass transport problem. These relaxations involve adding an extra optimization step over a small region around one of the marginal measures and they regularize the problem. We prove the tractability of this formulation for a wide class of cost functions. We also prove out-of-sample generalization results. Our formulation provides computationally tractable algorithmic insights involving the training of Wasserstein GANs. For example, we derive, using optimality principles, a threshold-based criterion which indicates that the generating networks should be trained less often while the actor-critic iterations are increased.

■ TC13

CC- Room 2B

Stochastics and Control in Financial Engineering

Sponsored: Applied Probability

Sponsored Session

Chair: Ciamac Cyrus Moallemi, Columbia University, New York, NY, 10027, United States

Co-Chair: Costis Maglaras, Columbia University, New York, NY, 10027, United States

1 - A Deep Learning Approach to Estimating Fill Probabilities in a Limit Order Book

Muye Wang, Columbia Business School, New York, NY, 10027, United States, Ciamac Cyrus Moallemi

Deciding between the use of market orders and limit orders is an important question in practical optimal trading problems. An important ingredient in making this decision is understanding the uncertainty of execution a limit order, that is, the fill probability or equivalently the distribution of the time-to-fill. We propose a data-driven approach based on recurrent neural networks to estimate the distribution of time-to-fill for a limit order conditional on the current market conditions. Using a historical data set, we demonstrate the superiority of this approach to several benchmark techniques.

2 - Unbiased Monte Carlo Estimator for Jump-Diffusions

Guanting Chen, Stanford University, Stanford, CA, United States, guanting@stanford.edu, Alex Shkolnik, Kay Giesecke

We develop and analyze an unbiased Monte Carlo estimator for functionals of jump-diffusion process with state-dependent drift, volatility, jump intensity and jump size. Under regularity conditions on the coefficient functions as well as the functional, we prove the unbiasedness and the finite variance property of the estimator.

3 - Optimal Execution in the Presence of a Limit Price

Seungki Min, Columbia Business School, 3260 Henry Hudson Parkway, The Arbor 3LB, New York, NY, 10463, United States, smin20@gsb.columbia.edu

We consider an optimal execution problem in the presence of a limit price. Here, the decision maker seeks to sell (respectively, buy) a given quantity of stock as quickly as possible, but is not allowed to trade at a price that is lower (resp., higher) than a given limit price. We characterize the optimal policy for this problem, and illustrate our results with numerical experiments.

■ TC14

CC- Room 302

Delegating New Product or Project

Sponsored: Manufacturing & Service Oper Mgmt

Sponsored Session

Chair: Shivam Gupta, University of Nebraska Lincoln, Lincoln, NE, 68588, United States

1 - Is Simplicity the Ultimate Sophistication? The Superiority of Linear Pricing

Behrooz Pourghannad, University of Minnesota, Rochester, MN, 55901, United States, behrooz@umn.edu, Guangwen Kong, Tony H. Cui

This paper studies a manufacturer's choice of the contract when facing a boundedly rational retailer. In a supply chain with a fully rational retailer, a wholesale price contract cannot perform better than buy-back and revenue sharing contracts. When the retailer is boundedly rational, we find that a wholesale price contract can dominate both buy-back and revenue sharing contracts. We characterize the condition under which a wholesale price contract is the optimal choice of the manufacturer. Our findings are supported by laboratory experiments in which human suppliers choose a contract to offer to computerized boundedly rational retailers.

2 - Service Design of Non-profits that Serve Distressed Individuals: under Earmarked Funds

Priyank Arora, University of Massachusetts Amherst, Amherst, MA, 01003, United States, parora@isenberg.umass.edu, Morvarid Rahmani, Karthik Ramachandran

Non-profit organizations that serve distressed individuals are driven to not only offer a variety of services, but also engage in advisory activities to minimize mismatches between services clients receive and their true needs. We investigate the effect of earmarked funds (that can be used only for the delivery of a specific type of service) on the portfolio and service design decision of resource-constrained NPOs.

3 - Content Sharing as a Competitive Strategy in the Age of Big Data

Mariia Petryk, University of Florida, Florida, FL, United States, mariia.petryk@ufl.edu, Emre M. Demirezen, Subodha Kumar

Competition becomes more collaborative in the era of big data. Businesses reduce the accessibility barriers to their content and integrate with peers. We explore the setting of two competing firms which are both hardware and content-platform providers. We find that cross-platform integration and content-sharing may result in higher satisfaction for the customer and additional profit streams for participating firms.

■ TC15

CC- Room 303

Negotiation Models and Analysis of Negotiators

Sponsored: Group Decision Making and Negotiation

Sponsored Session

Chair: Danielle Morais, Universidade Federal de Pernambuco, Recife - PE, 52020-212, Brazil

Co-Chair: Adiel Teixeira De Almeida, Universidade Federal de Pernambuco, Recife PE, 50630-970, Brazil

1 - Negotiation Protocol Based on Ordered Weighted Averaging

José Leão Silva Filho, Universidade Federal de Pernambuco, Caruaru, Brazil, zeleao@gmail.com, Danielle Morais

This study proposes a Negotiation Support framework to provide the negotiator with recommendations on making decisions in a negotiation process. To input this idea into negotiation protocols, this paper suggests the use of some concepts based on OWA (Ordered Weighted Averaging), where its weights are used to evaluate rankings of offers evaluation which depends only on its ranking position (from the higher to lower). It is expected that the support provided will aid the negotiator to make decisions during the negotiation process, to learn from the elicitation and his own behavior, in other words, the results obtained can help the negotiator improving his skills in the negotiation process.

2 - Development of an Integrative Negotiation Model for the Definition of Individual Actions in the Reverse Flow Channel

Marcele Elisa Fontana, Universidade Federal de Pernambuco, rua Governador Lopo Garro, Engenho do Meio, Caruaru, 50730-285, Brazil, marcelelisa@gmail.com, Wesley Douglas Silva

An integrative negotiation model was developed to define a set of individual actions in a shared responsibility view of waste management in the reverse flow channel. The Strategic Options Development and Analysis (SODA) and Soft Systems Methodology (SSM) methods were added to structure the problem, stimulate collaboration and integrate stakeholder perspectives and preferences into a learning process. Meanwhile, linear multi-objective programming (LMOP) has found a subset of individual actions. The model reached the Pareto Frontier solution satisfactory for all stakeholders simultaneously, which allowed the strengthening of the engagement between the parties.

3 - Assessing Negotiators' Preferences with Partial Information and Flexible Elicitation

Eduarda Frej, Universidade Federal de Pernambuco, Avenida Flor de Santana 148, Recife, Brazil, eafrej@cdsid.org.br, Danielle Morais, Adiel Teixeira De Almeida, Gregory E. Kersten

The aim of this work is to incorporate preferences elicitation with partial information to negotiation processes conducted with the INSPIRE system. Negotiators preferences would be evaluated considering a structured elicitation procedure based on the FITradeoff method during the offer exchanging process, which would help them to propose their offers to the other side. The idea is to improve the actual way in which preferences are assessed in the INSPIRE system, which is based on direct rating and consequently leads to inconsistencies in the results. The FITradeoff method uses partial information about the individual's preferences to build a recommendation, which results in time and effort saving.

4 - Supporting the Negotiation Process for Watershed Committees with Value-focused Thinking Application and Neurodecision Insights

Ana Luiza Andrade, Universidade Federal de Pernambuco, Recife, Brazil, analuiza93@hotmail.com, Marcella Maia Urtiga, Danielle Morais

Members from watershed committees (WSC) in Brazil need to make decisions regarding water allocation considering the availability of water and the rainwater accumulated in the reservoirs. A framework based on Value-focused Thinking is proposed to assist decision-makers (DMs) on structuring a water allocation problem, identifying issues to be negotiated which represent the interests of different sectors of society and behavioral decision making is explored by suggesting how neuroscience tools might be used to help the decision process. The framework promotes cooperation and reduces conflicts by having DMs interact with the purpose of increasing the beneficial results of the negotiation.

■ TC16

CC- Room 304

Emerging Topics in Service Operations

Sponsored: Manufacturing & Service Oper. Mgmt/Service Operations

Sponsored Session

Chair: Mor Armony, New York University, New York, NY, 10012, United States

1 - The Customer May Not Always Be Right: Customer Compatibility and Service Performance

Ryan Buell, Harvard Business School, Boston, MA, United States, rbuell@hbs.edu, Dennis Campbell, Frances X. Frei

This paper investigates the impact of customer compatibility - the degree of fit between the needs of customers and the capabilities of the operations serving them - on customer experiences and firm performance. Customers interacting with retail banks and quick service restaurants report relatively consistent satisfaction across transactions with specific firms, but some customers are habitually more satisfied than others. Further analysis reveals these customer-level differences in satisfaction are explained in part by differences in customer compatibility, and that the compatibility of a firm's customer base has meaningful implications for its long-run performance.

2 - Data-driven Priority Policies to Enhance Customer Service and Revenue Opportunities Using Past Customer Interaction Information

Seyed Emadi, University of North Carolina at Chapel Hill, Chapel Hill, NC, United States, Seyed_Emadi@kenan-flagler.unc.edu, Vinayak V. Deshpande, Brett Hathaway

While companies are increasingly customizing their offerings based on their customers' history of interactions, to our knowledge, the benefits of exploiting customer history in service systems to enhance customer service or revenue opportunities has not been demonstrated empirically. We fill this gap by using call center data to study history-based priority policies, which prioritize callers based on their predicted abandonment and redialing behavior. We find that compared to a first-come, first-served policy, certain history-based priority policies can simultaneously improve average waiting times and opportunities for agents to cross-sell additional products.

3 - What's in a Constraint? on the Ambiguity of Standard Delay Targets

Itai Gurvich, Cornell Tech, New York, NY, 10044, United States, gurvich@cornell.edu, Seung bum Soh

Service providers often formulate staffing problems as satisfization ones, where staffing is minimized subject to quality of service constraints. These constraints are an indirect mechanism to model customers' disutility from delay or, at least its structure (monotone, convex and so on). Standard satisfization formulations, we show are ambiguous-they have multiple solutions, each consistent with a different delay-disutility structure. Yet, practitioners (and researchers), in choosing one out of these multiple solutions and, implicitly impose a delay disutility structure. We seek to give a principled basis for these choices.

4 - When to Send a Patient Home? The Effect of Infection Risk on Hospital Length-of-stay

Mor Armony, New York University, New York, NY, 10012, United States, marmony@stern.nyu.edu, Galit Yom-Tov

Following treatment hematology patients face an increased risk of developing an infection. If a patient remains at the hospital his risk of catching an infection is higher than at home, but once an infection develops the mortality risk at the hospital is lower than at home due to quick access to appropriate treatment. We study the problem of dynamically determining discharge times for hematology patients subject to capacity constraints. We show that in an overloaded operating regime this dynamic problem reduces to a static problem with a simple solution of two-class two-discharge thresholds. We characterize the specific optimal solutions under empirically driven time-to-infection distributions.

■ TC17

CC- Room 305

MSOM ServOps/Spatial Service Systems: Ride-Hailing

Sponsored: Manufacturing & Service Oper. Mgmt/Service Operations

Sponsored Session

Chair: Ilan Lobel, New York University, New York, NY, 10012, United States

Co-Chair: Francisco Javier Castro, Columbia University, New York, NY, 10027, United States

Co-Chair: Omar Besbes, Columbia University, New York, NY, 10027, United States

1 - Dynamic Spatial Pricing in Ride-hailing Markets

Chen Chen, Duke University, Durham, NC, 27708-0120, United States, cc459@duke.edu, Santiago Balseiro, David Brown

We study dynamic pricing of resources distributed over a network of locations. Customers with private willingness-to-pay sequentially request to relocate one resource, and a revenue-maximizing service provider sets a price for each request. We focus on networks with a hub-and-spoke structure, and develop a dynamic pricing policy based on a Lagrangian relaxation. We show the policy loses no more than $O(\sqrt{(\ln n/n)})$ in performance when the number of spokes n and the number of resources grow at the same rate. Finally, we extend the approach to general networks with multiple hubs and spoke-to-spoke connections. We observe strong empirical performance on realistic examples based on data from RideAustin.

2 - Optimal Subscription Design for Ride-sharing Platforms

Shreyas Sekar, Harvard University, Cambridge, MA, 02138, United States, ssekar@hbs.edu, Hongyao Ma, David C. Parkes

In ridesharing platforms with dynamic pricing, there has been widespread interest in subscription mechanisms that offer riders a locked-in price. Yet, we lack an understanding of how such schemes can co-exist with a spot market. In this work, we present a systematic investigation of subscription pricing in ridesharing. We propose a two-period model where uncertain riders choose between subscribing in advance or participating upon realization of value. Our results present many insights on the use of subscription prices. We establish conditions under which subscription mechanisms improve the social welfare at equilibrium and develop a prescriptive framework for optimally setting these prices.

3 - Information Design for Spatial Resource Competition

Pu Yang, Cornell University, Ithaca, NY, 14850, United States, py75@cornell.edu, Krishnamurthy Iyer, Peter Frazier

Information design arises in economic settings where a better-informed sender designs mechanisms to share information with a group of agents to improve their total welfare. Motivated by ride-sharing, we study a setting where agents competing for a resource decide whether to explore a new location with unknown resource level. We (i) characterize the equilibrium strategies of agents under public and private information sharing mechanisms; (ii) study the structure of the optimal public and private mechanisms and (iii) demonstrate via analysis and numerical examples that randomized mechanisms achieve higher welfare than deterministic ones when agents' behaviors have negative externalities.

4 - Spatial Capacity Planning

Francisco Castro, Columbia University, Columbia School of Business, New York, NY, 10027, United States, Omar Besbes, Ilan Lobel

We study the link between capacity and performance for a service firm with spatial operations such a ride-hailing platform. We propose a state-dependent queueing model that captures spatial frictions and spatial economies of scale through the service rate. We find that SRS staffing does not balance server utilization and customer wait times in spatial systems. In them, pickup times increase the system load, and are an endogenous source of extra workload that leads the system to only operate efficiently if there is enough supply-demand imbalance. In heavy traffic, we show that to balance utilization and wait times a higher safety factor is required, proportional to the offered load to the power of 2/3.

■ TC18

CC- Room 306

Platform Operations

Sponsored: Manufacturing & Service Oper. Mgmt/Supply Chain

Sponsored Session

Chair: Robert Swinney, Duke University, Durham, NC, 27708, United States

1 - Designing Rewards-based Crowdfunding Campaigns for Strategic Contributors

Soudipta Chakraborty, Duke University, Durham, NC, 27708, United States, sc390@duke.edu, Robert Swinney

We study a model of rewards-based crowdfunding via a platform like Kickstarter. The creator of a crowdfunding campaign solicits pledges from contributors, and if total pledges exceed a pre-determined threshold, the campaign is successful, the creator receives all pledges and each contributor receives a reward. Otherwise, the campaign fails and contributors are refunded their pledges. We determine how a creator should design her campaign when the uncertainty of receiving the reward makes contributors behave strategically.

2 - Pricing and Prioritizing Differentiated Services When Customers Learn Socially

Gad Allon, University of Pennsylvania, Philadelphia, PA, 19104, United States, gadallon@wharton.upenn.edu, Koushiki Sarkar, Achal Bassamboo

Dissemination of information via social networks play a critical role in modern decision-making. We model the effects of social information in service differentiation under a queuing setting. We consider a profit-maximizing firm serving two groups of customers, where the customers observe service reviews from a subset of customers in each period and use that information to decide their action for the coming period. We study the equilibrium to which the system converges under social learning and compare it to the equilibrium under individual learning.

3 - Predicting Human Discretion to Adjust Algorithmic Prescription: A Large-scale Field Experiment in Warehouse Operations

Jiankun Sun, Northwestern University, Evanston, IL, 60201, United States, jiankun-sun@kellogg.northwestern.edu, Dennis Zhang, Haoyuan Hu, Jan A. Van Mieghem

Conventional optimization algorithms that prescribe order packing instructions focus on bin volume utilization yet tend to overlook human behavioral biases. We observed the order fulfillment operations at Cainiao, the logistics division of Alibaba. We found that for more than 5.8% of packages, workers deviated from the algorithmic prescriptions typically by switching to a larger bin than recommended. This switch increases packing time as well as material and environmental costs. We identify such behavioral biases, and propose a new algorithm that predicts human discretionary behavior using machine learning techniques to pro-actively adjust the algorithmic prescription.

4 - Verification of Truth in News: Crowd Sourcing vs. Platform Intervention

Jiding Zhang, The Wharton School, University of Pennsylvania, Philadelphia, PA, 19104, United States, jiding@wharton.upenn.edu, Senthil Veeraraghavan, Laurens G. Debo

Fake news and unverified information reduce new quality, and informedness of citizenry. One possible way of controlling the spread of fake news is encouraging readers to inspect and flag fake news. In this paper, we model readers as Bayesians who update their belief of a news article being untrue, based on the total readership and the time of the news being alive (not yet flagged). They are strategic in deciding whether to inspect the news. The platform inspects the news at the same time. We examine conditions where the inspection from the crowd/platform is more effective.

■ TC19

CC- Room 307

New Topics on Inventory Management

Sponsored: Manufacturing & Service Oper. Mgmt/Supply Chain

Sponsored Session

Chair: Shan Li, City University of New York, New York, NY, 10010, United States

1 - The Guaranteed Service Model as a Heuristic for the Stochastic Service Model

Yinan Liu, Lehigh University, Bethlehem, PA, 19144, United States, Lawrence V. Snyder

The stochastic service model (SSM) and the guaranteed service model (GSM) are the two most widely used models for optimizing base-stock levels in multi-echelon inventory systems. The SSM is generally more realistic but the GSM is more tractable. We study the question of whether the GSM is a good heuristic for systems that operate under SSM conditions. We conclude that the GSM usually a good heuristic in serial and assembly systems but may perform poorly in distribution systems. We also examine the question of how to set the demand truncation bound in the GSM, a critical parameter that has a large effect on the performance but is often overlooked in the modeling analysis.

2 - Optimizing Inventory in a Two-stage System

Kangye Li, Lehigh University, Bethlehem, PA, United States, kangyeli92@gmail.com, Lawrence V. Snyder

We formulate a two-stage inventory model with stochastic demand. Our model optimizes the inventory decisions at the downstream stage, assuming that the upstream stage follows its own policy and may experience stockouts. Using dynamic programming, we optimize the inventory policy numerically. We also consider a special case in which the upstream stage follows a base-stock policy and discuss the theoretical implications for the optimal policy at the downstream stage. Our study is motivated by the more complex problem of optimizing inventory in a multi-stage supply chain when some stages do not follow the optimal policy, as in the beer game.

3 - Stockout Risk Estimation and Repair Expediting for Repairable Spare Parts

Mustafa Hekimoglu, Kadir Has University, Istanbul, Turkey, mustafa.hekimoglu@khas.edu.tr, Gurhan Kok, Mustafa Sahin

Stockouts of repairable spares usually lead to downtime costs of capital products. Advance indicators of future stockouts combined with optimal repair expediting policies are crucial for achieving target service levels with reasonable costs. In this study, we first developed an advance stockout risk quantifier for repairable spare parts. Tests with empirical data indicate that the method is accurate in 83% of cases. Second, we developed an parameter optimization algorithm for a threshold-type repair expediting policy under minimum service level and maximum expedited demand constraints. The algorithm is proved to be efficient for finding optimum policy parameters in our empirical tests.

4 - The Commitment Conundrum of Inventory Sharing

Shan Li, City University of New York, Baruch College, New York, NY, 10010, United States, shan.li@baruch.cuny.edu, Kay-Yut Chen

In recent years, inventory sharing, in addition to the traditional within-firm model, also appears in the sharing-economy model where different firms can share their inventory via an internet platform. Two prominent issues, shaping the behaviors of inventory sharing systems, are the commitment of the transfer price and the commitment to share. In this paper we investigate, through a behavioral lens, the decisions of transfer price, order quantity and the resulting supply chain efficiency in different transshipment commitment scenarios. This study provides implication on the design of the commitment rules in decentralized inventory sharing platforms.

■ TC20

CC- Room 308

What You Need to Know to be a Scholarly Teacher

Sponsored: Education

Sponsored Session

Chair: Joseph Szmerekovsky, North Dakota State University, Fargo, ND, 58108-6050, United States

Co-Chair: Tim O Peterson, North Dakota State University College of Business, Fargo, ND, 58108, United States

1 - What is Scholarly Teaching?

Tim O. Peterson, Professor of Management, North Dakota State University, Faro, ND, United States, tim.o.peterson@ndsu.edu

This portion of the session will define scholarly teaching as compared to the scholarship of teaching. Next the idea of scholarly teaching will be applied to observed Teaching><Learning Connections which are problems or opportunities seen in a learning environment. I will share two examples from my teaching experience. One of those experiences was a problem in the learning process. The other was an opportunity to improve on the Teaching><Learning Transaction.

2 - What You Need to Know About Adult Learning to Be a Scholarly Teacher

Claudette M. Peterson, Associate Professor, North Dakota State University, Fargo, ND, United States, claudette.peterson@ndsu.edu

Academics and other professionals in operations research and analytics can increase the impact of their research, knowledge, and technical training by optimizing how they share that knowledge with others. Technical education usually does not include courses related how adults learn. This portion of the session will apply principles of adult learning to scholarly teaching in order to more effectively interpret and communicate the meaning of information for others. In addition, I will share research-based findings regarding the development of emerging adults (traditional college students) and how learning changes according to their stage of development.

3 - Scholarly Teaching to Support Systems Thinking and Information Systems

Jon W. Beard, Iowa State University, Ames, IA, United States, jwbeard@iastate.edu

In recent years we have become swamped with information. A thoughtful, systematic, yet flexible, approach is needed to cope with this wealth of information. This portion of the session uses Systems Thinking to explore scholarly teaching as a context to organize, interpret, and work with the information available and to recognize where gaps exist in our knowledge and understanding. A more systematic approach is especially important in this era of wide and growing use of information systems. Both real-world examples and material from the management literature are used to explore ways to employ scholarly teaching to support teaching, learning, and decision making.

4 - Scholarly Teaching in Transportation Science and Technology

Raj Bridgelall, Assistant Professor & Program Director, North Dakota State University, Fargo, ND, United States

Transportation systems has recently been undergoing a rapid transformation that integrate advancements in sensing, artificial intelligence, and communications technologies. The motivations classify into push and pull factors that drive business gains and address societal needs, respectively. In the context of scholarly teaching, the instructor developed a new push-pull-impedance framework to motivate and organize learning about factors that affect the evolution and adoption of smart transportation. The author will provide a specific example of using the framework to demonstrate learning about the potential societal impacts and implications of connected vehicle technology.

■ TC21

CC- Room 309

Emerging Topics in Supply Chain Risk Management

Sponsored: Manufacturing & Service Oper. Mgmt/iFORM

Sponsored Session

Chair: Panos Kouvelis, Washington University in St. Louis, Saint Louis, MO, 63130-4899, United States

Co-Chair: Danko Turcic, Washington Univ. in St. Louis, St. Louis, MO, 63130, United States

1 - Retailer Initiated Inventory-based Financing

Weiming Zhu, IESE Business School, Avenida Pearson 21, Barcelona, 08034, Spain, wzhu@iese.edu, Wei Luo

We study an innovative financing scheme in which a large retailer, such as JD.com, provides inventory-based lending to a small retailer selling through her own brick-and-mortar channel. We analyze the effectiveness of such financing scheme through a Stackelberg game, and explore its impact on operational decisions and contract design. Using datasets obtained from JD Finance, we provide evidence for small retailer's stockpiling behavior and verify the predictions from the theoretical results through reduced-form analysis.

2 - Operational Risk Management: Optimal Inspection Policy

Yuqian Xu, University of Illinois at Urbana-Champaign, Champaign, IL, 61820, United States, Youngsoo Kim

This paper studies the design of optimal inspection policy for financial service firm that aims to mitigate operational risk losses. The firm takes recurring inspections to check operational risk events, and the employee exerts efforts to avoid paying penalty for operational risk events. Both random and deterministic policies are considered.

3 - An Investigation of the BMW Supply Chain

Danko Turcic, Washington Univ. in St. Louis, Olin Business School, St. Louis, MO, 63130, United States, Panos Markou, Panos Kouvelis, Daniel S. Corsten

This paper develops a theory that explains how automakers apportion raw material cost fluctuations that their suppliers face, and empirically tests that theory using a unique data set of procurement contracts at BMW.

4 - Hedging Input Commodity Price Risk: An Equilibrium View

Stathis Tompaidis, University of Texas-Austin, McCombs School of Business, IROM Department, Austin, TX, 78712-1179, United States, Stathis.Tompaidis@mccombs.utexas.edu, Hamed Ghoddusi, Sheridan Titman

We present a model of a commodity processing chain with endogenously determined input and output prices and characterize the effectiveness of hedging policies that employ forward contracts on the price of the input. The minimum variance hedge depends on operational characteristics, such as the convexity of the production function, and on economic variables - the elasticity of supply and demand and the relative magnitude of input and output risks. The hedge can change over time as capacity utilization in the industry changes. We evaluate the effectiveness of our model for the crude oil to refined products supply chain.

■ TC22

CC- Room 310

Joint Session MSOM/SUS/Practice Curated: Operations Management and the Sustainable Development Goals

Sponsored: Manufacturing & Service Oper. Mgmt/Sustainable Operations

Sponsored Session

Chair: Andre Du Pin Calmon, INSEAD, Fontainebleau, 77300, France

Co-Chair: Gonzalo Romero, University of Toronto, Rotman, Toronto, ON, M4K 3H6, Canada

1 - Eliminating Lead Poisoning through Value Chain Innovation

Erica Plambeck, Stanford University, Graduate School of Business, Knight Management Center, Stanford, CA, 94305-7298, United States

Informal recycling of lead acid batteries and coloring (adulteration) of turmeric with lead chromate cause widespread lead poisoning in Bangladesh. Profitable value chain innovation could largely eliminate that lead poisoning.

2 - Non-ownership Business Models for Solar Energy

Safak Yucel, Georgetown University, Georgetown University, Washington, DC, 20057, United States, safak.yucel@georgetown.edu, Vishal Agrawal, Beril L. Toktay

In addition to the traditional sales model, solar power companies, such as SolarCity and Sunrun, have introduced innovative non-ownership business models: leasing and power purchase agreements. We study a solar power company's business model decisions and how they affect the environment, customers, and utility firms.

3 - Effective Distribution Models for the Base of the Pyramid

Olumurejiwa Fatunde, MIT, Cambridge, MA, United States, Andre Du Pin Calmon, Joann de Zegher, Gonzalo Romero

We partner with Essmart, a social enterprise distributing life-improving durable goods to Base of the Pyramid (BoP) consumers in India, to gather data and examine the current behavior of BoP retailers. Our goal is to conduct a field experiment to test the effectiveness of various distribution models.

4 - Timely After-sales Service and Technology Adoption: Evidence from the Off-grid Solar Market in Uganda

Amrita Kundu, London Business School, Regent's Park, PhD Office - MSO, London, NW1 4SA, United Kingdom, akundu@london.edu, Kamalini Ramdas

We empirically examine the extent to which timely after-sales service impacts technology adoption in emerging markets. We find: (1) Timely after-sales service is a strong driver of technology adoption in emerging markets, (2) Customers share their service experience with others in their network. This word-of-mouth mechanism explains our first result.

■ TC23

CC- Room 3A

Bayesian Learning and Decision Making

Sponsored: Decision Analysis

Sponsored Session

Chair: Canan Ulu, Georgetown University, Washington, DC, 20057, United States

1 - Learning and Information Spillover in a Technology Supply Chain

Wenxin Xu, The Hong Kong Polytechnic University, M507n, Hong Kong, Hong Kong, wenxin.v.xu@polyu.edu.hk, Dharma Kwon, Wenjie Tang

We consider a setting where one technology provider introduces her new technology to two manufacturers, who adopt this technology into their products. The manufacturers then release their products to the same consumer market and price compete with each other. The success of the new technology is uncertain, but the manufacturers can learn the profitability from some public speculations of how acceptable products carrying the new technology might be to the consumer market, or the performance of an earlier adopter. We examine the adoption timing strategies of the manufacturers as well as the pricing strategy of the technology provider.

2 - Markdown Policies for Demand Learning with Forward-looking Customers

Hongfan Chen, University of Chicago, Chicago, IL, 60615, United States, hongfan.chen@chicagobooth.edu, John R. Birge, N. Bora Keskin

We consider the markdown pricing problem of a firm that sells a product to a mixture of myopic and forward-looking customers. The firm faces an uncertainty about the customers' forward-looking behavior, arrival pattern, and valuations for the product, which we collectively refer to as the demand model. Over a multiperiod sales season, the firm sequentially marks down the product's price and makes demand observations to learn the underlying demand model. Contrary to common intuition, we show if the customers are forward-looking, the firm's profit loss due to demand model uncertainty can asymptotically vanish.

3 - Learning from Clickstream Data in Online Retail

Bharadwaj Kadiyala, University of Utah, Clear Water Bay, Kowloon, Salt Lake City, UT, United States, Dorothee Honhon, Canan Ulu

E-tailers now have the resources to record the sequence of clicks their online customers make, also known as their clickstream. Such detailed browsing information reveals customer preferences and, as such, can be used to improve product assortment and display decisions over time. In this paper, we consider a Bayesian framework to study how an e-tailer can draw inferences about customer preferences using clickstream and sales data, for utilitarian and hedonic product categories.

4 - Decision Making under Impending Regime Shifts

Canan Ulu, Georgetown University, Washington D.C., DC, United States, Sreyaa Guha, Matthias Seifert

We study insurance and asset pricing in dynamic environments when there is an impending regime shift. Risk attitudes and probability judgments of a regime shift occurring affect such pricing judgments. Integrating prospect theory with system neglect hypothesis to evaluate pricing judgments we predict distinct patterns of under- and overreaction in stable environments with noisy signals and in unstable environments with precise signals, which, we argue, are driven by the fourfold pattern of risk attitude postulated by prospect theory and by system neglect in probability judgments, respectively. We identify desirability of regime shifts as a critical factor that contributes to these patterns.

■ TC24

CC- Room 3B

Judgments and Forecasts

Sponsored: Decision Analysis

Sponsored Session

Chair: Asa Palley, Indiana University, Bloomington, IN, 47405, United States

1 - Is It Better to Elicit Quantile or Probability Judgments to Estimate a Continuous Distribution?

Saurabh Bansal, Penn State University, 405 Business Building, State College, PA, 16801, United States, sub32@psu.edu, Asa Palley

Two elicitation methods are commonly used to obtain subjective probability distributions from experts: (i) quantile judgments, and (ii) cumulative probability judgments, but a consensus on which format yields more accurate distribution estimates has not been reached. We report results from a series of experiments conducted with participants with a range of quantitative backgrounds to compare these elicitation formats for a variety of variables. We find that quantile judgments provided more accurate estimates of the full distribution, and identify the mechanism that drives this relative performance benefit.

2 - Naturalistic Noisy Signals

Blair Flicker, University of South Carolina, Columbia, SC, 75208, United States, blair.flicker@moore.sc.edu, Elena Katok

Private information (an important operational concept) is often conveyed via noisy signals in models and experiments. The typical "mechanical" implementation (adding mean-zero noise to a quantity of interest) does not reflect how many signals are conveyed. We propose a method for sending "perceptual" signals in laboratory experiments via informative images.

3 - Individual and Group Weighting in Crowd Forecast Aggregation

Pavel Atanasov, Pytho LLC, Brooklyn, NY, 19103, United States, pavel@pytho.io, Stephen Bennett, Andres Abeliuk, Mark Himmelstein, Fred Morstatter, Aram Galstyan, David Budescu, Mark Steyvers

Weighting individual estimates based on past performance has proven effective in improving the accuracy of aggregated forecasts. We examine nested designs, in which forecasters belong to groups that may vary in average accuracy. Using data from forecasting tournaments and related simulations, we examine algorithms that simultaneously infer weights at the individual and the group level, and define the conditions in which nested weighting improves accuracy compared to individual-only weighting. In general, nested weighting is expected to produce an accuracy boost when performance varies widely across groups, and when individual accuracy measures are sparse or unreliable.

4 - Leveraging Group Discussion to Boost the Wisdom of Crowds

Chengcheng Zhai, Kelley School of Business, Bloomington, IN, United States, zhaic@iu.edu, Asa Palley, Ruth Beer

Combining information from multiple individuals can improve judgment accuracy. We leverage a stylized analytical model of information to derive candidate aggregation procedures under different assumptions about how information is shared before and after a group discussion, and study these methods in an experiment.

5 - 20 Years of Expert-elicited Probability Assessments at Eli Lilly: Approach and Analysis of Performance

Charles Persinger, Senior Research Advisor, Eli Lilly & Company, Lilly Corporate Center, Indianapolis, IN, 46285, United States, cpersinger@lilly.com

Assessments of the probability of success of projects in drug development inform individual project decisions and portfolio management. Since 1997 Lilly has used an expert panel to assess these probabilities using an approach informed by the field of Decision Analysis. We discuss Lilly's approach and present analyses of more than twenty years of data from these probability assessments.

■ TC25

CC- Room 401

Applications in Big Data Analytics

Emerging Topic: Practice Curated Track

Emerging Topic Session

Chair: Grace Lin, Asia University, Wufeng, 41354, Taiwan

Co-Chair: Roger R Gung, University of Phoenix, Phoenix, AZ, 85048, United States

1 - Big Data Analytics-Based Pricing and Revenue Management

Roger R. Gung, University of Phoenix, Phoenix, AZ, 85048, United States, Chun-Che Huang

Using big data for better pricing is a critical strategy for revenue management. Nowadays commodity and service industries have been developing big data analytics-based pricing systems to optimize profit or return on investment. In this talk, we present a general methodology for pricing and revenue management using big data analytics. The methodology includes statistical models for predicting customer buying behavior and an optimization framework for optimizing profit or return on investment.

2 - Optimize Teaching Performance Using Big Data Analytics

Roger R. Gung, University of Phoenix, Phoenix, AZ, 85048, United States, Jixiang Fang

Evaluating teachers' effectiveness in the educational industry is difficult, because teachers might be assigned with high or low performing students. In order to filter out the impact of student quality factor, we developed the mixed effect model using student attributes as fixed effect and teacher impact as random effect. Based on the model outputs, teachers' performance ranking is used to guide the classroom assignment, so as to optimize overall student learning outcome. The variable ranking is used as the training guidance for low performing teachers.

3 - A Supply Chain Based Credit Rating Methodology

Grace Lin, Asia University, Wufeng, 41354, Taiwan, Han-Chao Lee, Ko-Yang Wang

Traditional credit rating methodology is mostly based on financial data. Due to limited financial data availability, it's been very challenging for small and medium businesses to get loans from financial organizations. In this talk, we will present a new credit rating methodology based on a combination of financial information and the supply chain information as well as other market and environmental information. We will also share the design of our 3rd party blockchain based supply chain financing platform.

■ TC26

CC- Room 4C-1

E-marketing

Contributed Session

Chair: Xin Wang, Stonehill College, Easton, MA, 02357, United States

1 - Enabling the Smart Grid Services with the Decentralized Blockchain Architecture

Lida Haghnegahdar, SUNY, Binghamton, NY, United States, Zahra Amjadi

Advanced forecasting, future energy storage, dynamic pricing, load management, and responding to the demands of the energy market are some of the characteristics of a smart grid. A reliable, service-oriented, secure, efficient, and cost-effective the modern smart grid system is always desired. One way to achieve these objectives is to implement a blockchain approach, with the emphasis of smart grid data flow monitoring and data center management. Such an approach provides a suitable environment with tools to manage and access data effectively. The objective of this paper is to introduce the power blockchain model: an energy system model based on enabling accessible service to computing resources.

2 - Complaint Handling in Consumer Finance – The Case of the Three Credit Bureaus

Zsolt Ugray, Associate Professor, Utah State University, Logan, UT, United States, zsolt.ugray@usu.edu, Xiaoyan Xu

Consumers are often mistreated by large financial companies. The three large credit bureaus are a special case by themselves as no citizen can avoid dealing with them if they want to participate in any mortgage, loan, bank, credit card or other financial transactions. Using quantitative and text analysis methodologies, we investigate how the three large credit bureaus respond to consumer complaints.

3 - Service Investment Strategy for Competing Online Retailers with Social Network in Multiple Periods

Ruiqi Hou, Dr., University of Science and Technology of China, Hefei, China, qiqimath@gmail.com

We investigate the impact of investments in service with two competing online retailers. Customers diffuse between different markets, based on purchasing experience and under the effect of social network. At the beginning of a period, the firms decide on investments costs. We distinguish two variants: one where both firms decide autonomously (Nash equilibrium) and a leader-follower (Stackelberg game) case. For both cases, the optimal investment cost, optimal profit per unit time and the effect on market share are calculated. We also solve the two cases without social network. Numerical analysis shows that both firms invest more when social network exists and higher profits are gained.

4 - A Social Media Analysis of Measles' Outbreak in 2018-2019

Xin Wang, Stonehill College, 320 Washington Street, Easton, MA, 02357, United States, Zhong Justin Ren

We apply social media analytics to study public reactions to the recent measles outbreak. The social media analytics methodologies employed include descriptive, content and network analyses. The descriptive analysis describe the users' characteristics and basic behavior profiles. The content analysis reveal the major topics and extract the hidden semantics from the text. The network analysis explore the degree of a user's connections as well as help identify the most influential users. This research not only will provide insights on public sentiments toward vaccination but also shed light on how policy makers can understand and influence public attitude toward disease prevention measures.

■ TC27

CC- Room 4C-2

E-commerce

Sponsored: Service Science

Sponsored Session

Chair: Jingran Zhang, Marshall University, Huntington, WV, 25755, United States

1 - Third-party Sellers Strategic Decision-making in E-commerce Platform

Jingran Zhang, Marshall University, Huntington, WV, 25755, United States, zhangjin@marshall.edu

E-commerce has grown rapidly. Leading online retailers, such as Amazon and JD.com, has changed the traditional retailing models, along with the remarkable sales growth. Online retailer platform provides three strategies to process and fulfill customer orders: sell by and ship from the first party retailer, sell by third-party sellers and ship from the first-party website or sell by and ship from the third-party retailers. A strategic decision model between the last two methods is established by forecasting demand and the value of replenishment and quick response to customer orders to maximize the profit of third-party sales and order fulfillment performance.

2 - Assigning Online orders to Fulfillment Centers for Optimal Inventory Positioning

Sevilay Onal, University of Illinois Springfield, Springfield, IL, United States

Online orders have been assigned to fulfillment centers based on the proximity of the delivery location. We analyzed methods to improve multi-period fulfillment performance by forecasting future orders for optimal inventory positioning.

3 - The Digital Marketplace: The Past, Present and Future Future

Lasse Mitronen, Aalto University School of Business, Espoo, Finland, lasse.mitronen@aalto.fi, Mikko Hänninen, Stephen K. Kwan

We are now witnessing increased disintermediation in the retail value-chain as new entrants, like digital marketplaces, are applying advances in information technology to create novel combinations of value to end-customers, simultaneously converging the front and backstage activities in the service system. We develop an understanding of how digitalization is enabling firms to integrate the online and offline channels and succeed in creating a more coherent and personalized customer experience. We argue that a new stage in the service system is emerging where the online and offline domains are converging to create a more coherent customer experience.

4 - Managing Queues with Static Delivery Guarantees

Mehdi Hosseinabadi Farahani, University of Texas at Dallas, Richardson, TX, United States, mehdi@utdallas.edu, Milind Dawande, Ganesh Janakiraman

We study the problem of managing queues in online food ordering services where customers, who place the order online and pick up at the store, are promised a common due-date lead time. The objective is to minimize the long-run average earliness and tardiness costs incurred by the customers. Due to the difficulty of implementing sophisticated policies in practice, we investigate the performance of easily-applicable heuristic policies. Our results show that a simple policy, that starts serving a customer as soon as the time remaining to the due date falls below a threshold, yields near-optimal solutions.

5 - Scheduling Truck Docking Times and Package Loading for Outbound Operations

Daniel Chen, Amazon.com, Seattle, WA, United States, chonglic@amazon.com, Mehmet Tolga Cezik

In a warehouse, packages are sent to the outbound dock and require loading onto trucks going to the appropriate destination with deadlines. These packages can be loaded directly (preferable but less flexible), or stacked for later loading. Loading can only occur when trucks are docked at a limited number of doors. We propose a MIP to assign trucks to doors and schedule both types of loading. The MIP solves quickly on real-world problems for an online retailer. Under some simplifying assumptions, the formulation simplifies to one with a totally unimodular constraint matrix, which implies that the LP relaxation is integral. We further investigate various other improvements and extensions to the model.

■ TC28

CC- Room 4C-3

Stochastic Models of Manufacturing & Service Operations Management

Sponsored: Service Science

Sponsored Session

Chair: Xu Sun, University of Florida, Gainesville, FL, 10027, United States

1 - Beyond Safety Drivers: Staffing a Teleoperations System for Autonomous Vehicles

Andrew Monroe Daw, Cornell University, Ithaca, NY, 14853, United States, amd399@cornell.edu, Robert Hampshire, Jamol Pender

Driverless vehicles promise a host of societal benefits including improved safety, increased accessibility, greater productivity, and higher quality of life. As this new technology approaches widespread public deployment, both industry and government are making provisions for teleoperations systems in which remote human agents provide assistance to driverless vehicles, including via human-in-the-loop artificial intelligence systems. We address the problem of staffing such a remote support center. By establishing a novel connection from queueing models to storage processes, we determine staffing levels by calculating the probability that the workload in the system exceeds capacity.

2 - Perfect Sampling for Hawkes Queue

Xinyun Chen, Chinese University of Hong Kong, Shenzhen, Shenzhen, China, chenxinyun@cuhk.edu.cn

Motivated by the applications in social media, healthcare and financial systems, queueing models with autoregressive arrivals, such as the Hawkes or shot-noise-driven arrivals, have been studied in several recent works. So far, there is no analytic approach to compute the stationary distribution of single-server queues. In this talk, we propose a perfect sampling algorithm that generates i.i.d. samples exactly following the stationary distribution of single-server queues with autoregressive arrivals.

3 - Generalized Fractional Brownian Motion as Scaling Limits of Nonstationary Shot Noise Processes

Guodong Pang, Penn State University, Industrial and Manufacturing Engineering, University Park, PA, 16802, United States, Murad Taqqu

We introduce generalized fractional Brownian motions which preserve the self-similarity property but instead have non-stationary increments. They are defined via the integral representations with respect to Gaussian random measures. They arise naturally as scaling limits for a class of nonstationary shot noise processes with power-law variances. The proof of weak convergence relies on new maximal inequalities for stochastic processes in the space D whose upper bounds involve finite set functions with a superadditive property, instead of finite measures in the classical results (Billingsley, 1999). (This is joint work with Murad Taqqu at Boston University.)

4 - Differentiating the Quality of Service in Multiclass Queues: A Queue-ratio-based Scheduling Policy

Xu Sun, Assistant professor, University of Florida, Gainsville, FL, United States, Yunan Liu

Motivated by large-scale service systems, we study a multi-class queueing system having time-varying arrivals. Our objective is to devise appropriate staffing and scheduling policies to achieve differentiated service levels for each customer class. For this purpose, we propose new staffing and scheduling policies that are both time dependent (coping with the time variability in arrival pattern) and state dependent (capturing the stochastic variability in service times and arrival times). Effectiveness of our proposed staffing and scheduling policies is substantiated by heavy traffic limit theorems (as the system scale increases).

■ TC29a

CC- Room 400

Forecasting II

Contributed Session

Chair: Zhengde Zhao, University of Washington, Seattle, WA, 98105, United States

1 - Employment Analysis Based on Panel Data in the Background of Industry 4.0

Rongyan ZHOU, CentraleSupélec, Université Paris-Saclay, Gif-sur-Yvette, France, rongyan.zhou@centralesupelec.fr, Julie Stal-Le Cardinal

Although Industry 4.0 will bring a great of convenience to our lives, the unemployment brought by new technologies is concerned by the public. Whether the new jobs created by the industry 4.0 can make up for the losses caused by technical unemployment; what is the difference in the new job opportunities created by investment of industry 4.0 in different regions is focused in this paper. The panel data is applied in the study, and the study found that the EU faced the most serious unemployment problem brought by the industry 4.0 technologies, followed by NAFTA, then SAARC and East Asia. Furthermore, the study describes the possible reasons of the difference and proposes future research directions.

2 - An Adaptive Event Prediction Clustering Algorithm Based on Bayesian Network

Xing Yang, Tsinghua University, Beijing, China

Forecasting events requires expressing event temporal-causal relationships and capturing event temporal natures. First, different event types perform variously in temporal property. Second, relative time and absolute time should exist together to express them. Third, small data requires clustering for precise prediction in some cases. To address them, we present an adaptive clustering algorithm based on Bayesian network by measuring the event similarities, and divide events into two types, timing events and random events. Experimental results show that by clustering similar events and classifying event types, the proposed model leads to a significantly improved performance.

3 - Demand Forecasting of New Products Based on Model-driven Clustering and Feature-based Classifying

Yun Zhou, School of Management, Zhejiang University, Hangzhou, China, zhouyun2015@zju.edu.cn, Weihua Zhou, Hongyan Dai

This paper proposes a forecasting framework for new products based on model-driven clustering. Traditional studies generally adopted feature-, category-based or data-driven clustering to group products for model training. However, these frameworks mainly focus on operationalizing "similarity" between products, which is not necessarily between the model of products. We attempt to approach model "similarity" by leveraging the correlation vector with each component generated from the pair of demand and a single feature for clustering and feature-based classifying. The results indicate that the proposed clustering algorithm significantly outperforms other extant clustering methods.

4 - HHT-enhanced Machine Learning Methods for Financial Time Series

Zhengde Zhao, PhD Student, University of Washington, Seattle, WA, United States, zdzhao16@uw.edu, Tim Leung

In this paper, Hilbert-Huang transform (HHT), consisting of empirical mode decomposition (EMD) and Hilbert spectral analysis, is modified to analyze non-stationary financial time series, and is integrated into machine learning techniques, such as support vector machine (SVM), to identify useful features for prediction. Examples show that HHT-enhanced method can significantly improve the accuracy of prediction.

■ TC30

CC- Room 6A

Tutorial: Scheduling an Overloaded Multiclass Many-Server Queue with Impatient Customers

Emerging Topic: Tutorials

Emerging Topic Session

1 - Scheduling an Overloaded Multiclass Many-Server Queue with Impatient Customers

Amy R. Ward, University of Chicago, Marshall School of Business, Chicago, IL, 90089-0809, United States, Amber L. Puha

We describe a fluid model with time-varying input that approximates a multiclass many-server queue with time-varying arrivals (specifically, the multiclass G/GI/N +GI queue). We show how to use the restricted fluid model with constant input rate to approximately solve scheduling control problems for a queue with constant arrival rate. The key is to characterize the invariant states of the fluid model, because they typically provide an approximation to the mean steady-state behavior of the queue under a wide range of scheduling policies. The resulting fluid control problem motivates using a static priority scheduling policy when the objective is to minimize the long run average abandonment rate, but may motivate a different class of scheduling policies when there are also holding costs. We end by discussing several open problems.

■ TC31

CC- Room 6B

Applications in Military Operations Research

Sponsored: Military and Security

Sponsored Session

Chair: Paul Goethals

1 - Saturation Analytics for Security Operations

Paul L. Goethals, United States Military Academy, West Point, NY, 10996, United States, paul.goethals@westpoint.edu, Natalie M. Scala, Nita Yodo

In the contemporary security environment, the role of sensor technology in both the physical domain and the realm of cyberspace is growing in necessity and popularity. One factor that relates to the ability and effectiveness of sensors is the principle of saturation - it is tied directly to the attributes of detection capability, target identification, and analytical precision. This research examines several potential methods for modeling and measuring the degree of saturation and describes its application to several different security problems.

2 - Empowering Election Judges to Secure Our Elections

Natalie M. Scala, Associate Professor and Graduate Program Director, Towson University, Dept. of e-Business and Technology Management, Towson, MD, 21252, United States, natalie.scala@gmail.com, Dehlinger Joshua

Training modules for polling place elections equipment are developed in partnership with a mid-sized Maryland county using optical scanners, and the efficacy and effectiveness of the educational modules are tested via a pre-post test and usability study. The goal of the research is to empower Election Judges to take a proactive role in back-end security and encourage widespread adoption of threat training. The more aware Election Judges are to threats that pertain to their specific role and the more knowledgeable they are to properly handle these threats, the more secure our elections can be.

3 - Implementing a Vision to Create and Deploy the Airport Risk Assessment Model (aram)

Robert T. Brigantic, Pacific Northwest National Laboratory, Richland, WA, 99352, United States, robert.brigantic@pnnl.gov

This presentation will review a vision enabled by our sponsor, U.S. Department of Homeland Security, Science and Technology Directorate (DHS S&T), and established by working closely with our partner stakeholders (e.g., TSA) for a tool that quantifies the risk from terrorist threats at U.S. airports and then optimally deploys resources to reduce this risk. This tool is called the Airport Risk Assessment Model (ARAM). This presentation will also outline the methods for quantifying key risk components, along with resource effectiveness. Finally, we will discuss the potential extensions of ARAM to other domains that are applicable to a range of military and civilian critical infrastructure systems.

4 - Hybrid Optimization for Radio Channel Assignment in Contested Environments

Paul J. Nicholas, Chief Scientist, Large-Scale Analytics Systems, Johns Hopkins University Applied Physics Laboratory, Laurel, MD, United States, Karla L. Hoffman

The ability to efficiently allocate electromagnetic channels for radio communications is heavily dependent on co-channel interference, i.e., interference between two radios using the same channel. This problem is even more challenging in contested or degraded EM environments, as may be experienced in combat or dense urban environments. We present a new hybrid method to solve this problem via local neighborhood heuristics and constraint programming techniques, and provide performance results using realistic data sets from a large U.S. Marine Corps operational scenario.

■ TC32

CC- Room 6C

Get Involved with INFORMS Professional Development

Emerging Topic: INFORMS Special Sessions

Emerging Topic Session

1 - Get Involved with INFORMS Professional Development

Bill Griffin, INFORMS, Catonsville, MD, United States

Do you have an idea for a new professional development course? Have you taught a course that you think would improve professional practice? Do you want to hear from others who are closely engaged with INFORMS on the latest in professional development? If so, join the INFORMS Professional Development Committee and learn about topics under consideration for course development such as AI and Fraud Detection. Learn how you can propose a new course or become an instructor. Brief presentations on the current work of the committee and possible future course content will be followed by time for discussion and feedback.

■ TC33

CC- Room 602

Quantum Computing Architectures & Algorithms

Sponsored: Optimization/Computational Optimization and Software

Sponsored Session

Chair: Aaron Lott, D-Wave Systems, Palo Alto, CA, 94303, United States

1 - Challenges and Opportunities for Hybrid Quantum-classical Discrete Optimization and Machine Learning

Masoud Mohseni, Google Inc, Vencie, CA, 90291, United States

We present an overview of our progress on quantum-inspired and quantum-assisted algorithms for optimization and machine learning at Quantum AI Lab at Google. We develop an end-to end quantum-inspired discrete optimization platform that uses an interplay of local and non-local thermal updates to sample from inaccessible low-energy states of spin-glass systems that encode high-quality solutions of certain hard combinatorial optimization. We introduce several new techniques for quantum circuit learning on Noisy Intermediate-Scale Quantum (NISQ) processors. We perform metalearning on parameterized quantum circuits via black-box optimization with classical recurrent neural networks. We develop layerwise learning on quantum neural networks to tackle the problem of vanishing gradients. We provide several applications of such quantum models for characterization of the dynamics of NISQ devices and classification of quantum data.

2 - Quantum-Inspired Optimization

Helmut Katzgraber, Principal Research Manager, Microsoft Quantum, Redmond, WA, United States

The advent of the first useful quantum computing devices has resulted in an arms race with classical algorithms on traditional computing hardware. While near-term quantum devices might revolutionize, e.g., optimization and quantum chemistry, tackling many applications will directly depend on either hybrid or purely classical computing techniques. Inspired by these recent exciting developments, a variety of new classical algorithms have emerged. In this talk an overview on quantum inspired methods and their applications is given.

3 - Putting Quantum Computing in your Toolbox

Aaron Lott, D-Wave Systems, Palo Alto, CA, 94303, United States

We describe relationships between statistical physics and quantum annealing to provide insight into areas where quantum computation and simulation may play a role in solving industrial problems. We present an overview of the D-Wave 2000Q quantum computer architecture and discuss several optimization and machine learning algorithms that have been designed to leverage current and future D-Wave quantum computers. We outline the suite of software tools and cloud services that are available for researchers and developers to start assessing the technology today.

4 - Quantum Algorithms for Solving Mathematical Programming Problems

Pooya Ronagh, 1QBit, Waterloo, ON, Canada

We present quantum algorithms for solving mathematical programming problems that arise frequently in machine learning applications such as structured prediction. We analyze the computational complexity of these algorithms and show that they achieve a quadratic speed-up in the size of the label space for the structured prediction task. We also show that our method attains an almost optimal convergence rate with respect to the precision of the solution. We use these theoretical results and additional numerical experiments to assess the applicability of our quantum algorithms to solving real-world problems.

■ TC35

CC- Room 604

Advances in Mixed Integer Nonlinear Programming

Sponsored: Optimization/Integer and Discrete Optimization

Sponsored Session

Chair: Robert Hildebrand, VIrginia Tech, Blacksburg, VA, 24061, United States

1 - New Relaxations for Composite Functions

Mohit Tawarmalani, Purdue University, West Lafayette, IN, 47907-2076, United States, Taotao He

We introduce a composite relaxations that are a tighter way to relax composite functions than factorable relaxations. The relaxation encodes inner functions structure in terms of underestimators and their bounds and uses this structure to relax the outer-function. We show that these relaxations are particularly suitable for MIP discretization. Moreover, these relaxations provide ways to improve relaxation hierarchies.

2 - Compact Disjunctive Approximations to Nonconvex Quadratically Constrained Programs

Hongbo Dong, Assistant Professor, Washington State University, Pullman, WA, 98103, United States, Yunqi Luo

We propose a new approach, namely Compact Disjunctive Approximation, to approximate nonconvex Mixed-Integer Quadratically Constrained Programs (MIQCPs) to arbitrary precision by convex MIQCPs (i.e., all quadratics are convex). The novelty of our method lies in a compact lifted mixed-integer formulation for approximating the (scalar) square function, exploiting rotational symmetry in a similar fashion as in the BenTal-Nemirovski approximation of second-order-cones. We implement (with JuMP+Julia) an adaptive refinement algorithm. Promising numerical results are reported on several classes of synthetic instances used in the literature.

3 - A Convex Integer Programming Approach for Optimal Sparse PCA

Guanyi Wang, Georgia Institute of Technology, 500 Tech Parkway, Atlanta, GA, 30332, United States, gwang93@gatech.edu

Principal component analysis (PCA) is a widely used dimensionality reduction method. To enhance additional interpretability, it is desirable to consider the sparse principal component analysis (SPCA). Unlike the PCA, the SPCA is NP-hard. Heuristics cannot give guarantees via dual bounds. The dual bounds are only available via hard-to-scale semidefinite programming (SDP) relaxations. We present a framework that involves solving convex integer programs (CIP) to produce dual bounds. We show worst-case results on the quality of the dual bound obtained by CIP. In practice, the CIP model performs better than worst-case performance, and SDP bounds on some cases with shorter running-time.

4 - On Exact Solution and Feasibility of Polynomial Optimization Problems

Daniel Bienstock, Columbia University, New York, NY, 10027, United States, derdano@gmail.com

We discuss ongoing work on solving polynomial optimization problems. A surprisingly tricky issue is the relationship between accuracy (feasibility) and correctness of solution. We discuss theoretical work and computational experiments.

■ TC36

CC- Room 605

Data-driven Optimization Under Uncertainty

Sponsored: Optimization/Optimization Under Uncertainty

Sponsored Session

Chair: Hoda Bidkhori, University of Pittsburgh, Pittsburgh, PA, United States

1 - A Study of Distributionally Robust Multistage Stochastic Optimization

Yongpei Guan, University of Florida, Gainesville, FL, 32611, United States, Kezhuo Zhou, Jianqiu Huang

In this paper, we focus on a data-driven risk-averse multistage stochastic programming (RMSP) model considering distributional robustness. We optimize the RMSP over the worst-case distribution within an ambiguity set of probability distributions constructed directly from historical data samples. We reformulate it into a deterministic equivalent that contains a series of convex combination of expectation and conditional value at risk (CVaR), which can be solved by a customized stochastic dual dynamic programming (SDDP) algorithm.

2 - Tight and Tractable Bounds for Weighted Sums of Dependent Bernoulli Random Variables

Arjun Ramachandra, Singapore University of Technology and Design, Singapore, 439959, Singapore

Sums of Bernoulli random variables have been extensively studied as part of probability theory with applications in computer science, risk management, reliability systems, stochastic programming and graph theory. In this talk, we investigate tight bounds on weighted sums when the variables are dependent and the weights are any real numbers while assuming univariate and tree-type bivariate marginal information of the n variables. We develop tight bounds in these cases.

3 - Effective Scenarios in Multistage Distributionally Robust Optimization with Total Variation Distance

Guzin Bayraksan, The Ohio State University, 210 Baker Systems, 1971 Neil Avenue, Columbus, OH, 43210-1271, United States, bayraksan.1@osu.edu

Traditional multistage stochastic optimization assumes the underlying probability distribution is known. However, this distribution is often not known or cannot be accurately approximated. Distributionally robust optimization (DRO) addresses this issue by considering a set of possible probability distributions. We study multistage convex DRO with a finite set of scenarios, where the distributional ambiguity is modeled stagewise by the total variation distance on conditional probability distributions. We illustrate that not all but only some scenarios have an effect on the optimal value, and we formally define this notion. We illustrate the results on finance and energy problems.

4 - Data-driven Optimization with Distributionally Robust Stochastic Dominance Constraints

Chun Peng, PhD, HEC Montreal, Montreal, QC, Canada, chun.peng@hec.ca, Erick Delage

Optimization with stochastic dominance constraint (SDC) has been received increasing attentions on managing risk. Instead of knowing fully probabilistic description of uncertain outcome, we propose a novel optimization framework for problem with distributionally robust SDC in a data-driven context, which can be presented as a two-stage robust model under Wasserstein metric. Applying finitely adaptive policy, we derive the adaptive robust optimization formulation that motivates us to develop an iterative partition-based Branch-and-Bound method. We also propose several extended variants under different distributional settings and verify our framework for portfolio selection problem.

5 - Online Assortment Optimization with Reusable Resources

Xiao-Yue Gong, Massachusetts Institute of Technology, Cambridge, MA, 02139, United States, xygong@mit.edu, Vineet Goyal, Garud N. Iyengar, David Simchi-Levi, Rajan Harish Udwani, Shuangyu Wang

We have n capacitated substitutable reusable products. A sequence of users arrive. We offer an assortment St to each user, who selects a product based on their preference model (potentially adversarially chosen) and uses the product for some periods. The usage times of a product is i.i.d and only depends only on the product selected. We want to maximize the expected cumulative revenue. We show that a simple myopic policy achieves at least 1/2 the expected revenue of the optimal policy that knows the sequence of users and the usage time distributions with a coupling queue technique. We also show the assumption that the usage time only depends on the product is necessary for a nonzero competitive ratio.

6 - Tight and Tractable Bounds for Weighted Sums of Dependent Bernoulli Random Variables

Arjun Kodagehalli Ramachandra, Singapore University of Technology and Design, Singapore, arjun_ramachandra@mymail.sutd.edu.sg

In this talk, we investigate tight bounds on weighted sums of Bernoulli dependent variables assuming univariate and tree-type bivariate marginal information of the n variables. When only univariate information is available, we exploit the structure in the dual of an exponential size primal, suitably transforming it to a compact LP. An interesting application of split dependency among variables is presented. A special case of weights results in tight bounds for the occurrence of at least k out of n events for which we recreate an existing closed form result using order statistics. A similar concept is used to improve on best known analytical bounds with pairwise independence.

■ TC37

CC- Room 606

Optimization Techniques in Power System Applications under Uncertainty

Sponsored: Optimization/Optimization Under Uncertainty

Sponsored Session

Chair: Bowen Li, University of Michigan, Lemont, IL, 48105, United States

1 - Truly Robust AC Optimal Power Flow

Line A. Roald, University of Wisconsin-Madison, Madison, WI, 87544, United States, Dongchan Lee, Konstantin Turitsyn, Daniel K. Molzahn

We consider the robust AC OPF problem, where particularly challenging aspect is to guarantee existence of a solution to the non-linear, implicit AC power flow equations for all possible realizations of the uncertain power injections. We use so-called convex restrictions, which defines a convex inner approximation to the AC feasible region in power injection space (without limiting assumptions on nodal power balance), and devise a sequential solution algorithm which provide rigorous robustness guarantees. Empirical results using a variety of test cases demonstrate the algorithm's fast convergence, scalability, and limited conservativeness.

2 - Efficient Algorithm for Stochastic Climate Adaptation Problem on Coastal Power Networks

Bowen Li, Argonne National Laboratory, 9700 Cass Avenue, Lemont, IL, 60439, United States, bowen.li@anl.gov, Russell Bent, Ruiwei Jiang, Johanna Mathieu, Harsha Nagarajan

We develop an efficient algorithm to solve a multi-period power system adaptation problem (i.e., bus hardening and expansion) that is scalable in the problem dimension and scenario size. The objective of this problem is to improve the resiliency of coastal power networks facing potential threats of sea level changes and storm surge events. The problem is difficult to solve because it contains a large number of constraints and discrete variables. To speed up the computation, we improve the problem formulation and develop a decomposition and cutting-plane based algorithm using the special ordered sets.

3 - Solving Chance-constrained Optimal Power Flow Problems via a Smooth Nonlinear Approximation

Alejandra Pena-Ordieres, Northwestern University, C210, Evanston, IL, 60208, United States, Daniel Molzahn, Line Roald, Andreas Waechter

The increasing levels of fluctuating renewable energy make managing uncertainty in power injections an important concern to power system operators. In this talk, we address this uncertainty via a chance-constrained formulation of the optimal power flow problem. We avoid making assumptions on the distribution of the uncertainty by using a sample-based approach. Our formulation is designed to satisfy all the constraints simultaneously for a pre-determined probability. We use an Sl1QP-type trust-region algorithm that has proven to perform well in practice and that scales favorably with the number of samples. We illustrate the performance of our method on the 118-bus MATPOWER network.

4 - Stochastic Defense Against Complex Grid Attacks

Mauro Escobar, Columbia University, New York, NY, 10027, United States, me2533@columbia.edu, Daniel Bienstock

We describe stochastic defense mechanisms designed to detect sophisticated grid attacks involving both physical actions (including load modification) and sensor output alteration. The initial attacks are undetectable under a full AC power flow model even assuming ubiquitous sensor placement, while hiding large line overloads. We first show that such attacks can be computed in the case of large transmission systems. The defensive techniques apply network control actions that change voltages in a random fashion, and additionally introduce (random) low-rank corrections to covariance matrices.

■ TC38

CC- Room 607

Optimization in Unmanned Aerial Systems (UAS) Applications

Sponsored: Optimization/Optimization Under Uncertainty

Sponsored Session

Chair: Yanchao Liu, Detroit, MI, 48214, United States

1 - Integrated Routing and Charging Scheduling for Autonomous Electric Aerial Vehicle System

Jun Chen, San Diego State University, 5500 Campanile Drive, San Diego, CA, 92182, United States, jun.chen@sdsu.edu

Autonomous electric aerial vehicles (EAVs) are expected to bring fundamental changes to city infrastructures and daily commutes. Currently, the EAVs, including the delivery drones and the air taxi, are all under limited battery endurance and vertiport capacity, which is insufficient for long-range commutes. In this paper, we propose a joint scheduling methodology to handle the optimal routing and charging tasks for the Autonomous EAV System. By considering the unique characteristics of EAVs, the joint optimization problem can effectively utilize the energy. The problem is formulated as a mixed integer linear program and solved by a distributed algorithm based on dual decomposition method.

2 - Safety-assured Routing Automation for High-density Omnidirectional UAV Traffic

Yanchao Liu, Assistant Professor, Wayne State University, Detroit, MI, 48214, United States, yanchaoliu@wayne.edu

This paper presents a mixed integer programming (MIP) model that comprehensively characterizes all relevant aspects of the business scenario, and proposes an optimization-driven, progressive algorithm for online fleet dispatch operations. The model endogenously accounts for geometry and mobility and therefore permits dynamic input of order information with arbitrary pickup and delivery locations. The model is augmented with special constraints and an artificial objective function which effectively relay the system states between successive time horizons. The algorithm is validated through simulation case studies and is shown to meet the design objectives.

3 - Optimal Landing Algorithms for UAV Fleets

Zhenyu Zhou, Wayne State University, Detroit, MI, United States, zyzhou@wayne.edu, Yanchao Liu

Drone fleets will be increasingly used for delivery and urban air mobility. To prove airworthiness of fleet operations, it is critical to have in place a robust fleet-level failsafe mechanism. This paper investigates the problem of quickly landing a large fleet of drones as if in emergency. We consider factors such as the spatial distribution of drones, capacity of the landing depots and inter-vehicle collision avoidance. The problem is formulated as a series of optimization models, and fast and robust algorithms are proposed for near real-time solution. We furthermore integrate the algorithms in a fleet management platform and verify their practical performance in simulated and real flight tests.

4 - Path Planning for Package Delivery UAVs in Urban Environment

Fang He, City University of Hong Kong, Tat Chee Avenue, Kowloon, Hong Kong
Fang He, Shanghai Jiao Tong University, Shanghai, China, Lishuai Li, Yongbiao Lv, Lei Zhang, Gang Xiao

Using unmanned aerial vehicles (UAVs) for autonomous package delivery in urban environment is emerging. It offers a range of benefits, e.g. reduced road congestion and pollution, enabling agile services. However, a key challenge is how to scale up operations in high-density urban areas. We propose a modified Lazy Theta* grid search algorithm, coupled with a priority ordering algorithm and an iterative searching scheme, to solve the multi-path planning problem between depots considering complex urban environment. Simulation shows good performance in terms of quality and speed. The proposed method is also tested in real urban maps.

■ TC39

CC- Room 608

Transportation, Operations III

Contributed Session

Chair: Darweesh E Salamah, Mississippi State University, McCain, Mississippi State, MS, 39763-9542, United States

1 - Transportation Improvement for Patients at a Safety Net Family Health Center

Jia Guo, University of Texas-Austin, Austin, TX, United States, jia.guo@utexas.edu, Jonathan F. Bard, Douglas Morrice

In this work, we investigate options to improve transportation service for patients at Family Health Center (FHC) with UT Medical School in San Antonio. We first analyze data and conduct logistic regressions to find the impact of transportation factors on cancellations and late arrivals. Next, we develop a TSP to find shuttle routes within the poorest neighborhood of FHC. The solution includes number of vans in each route. In addition to regular multiple TSP constraints, the IP model includes van capacity, route time limit and shuttle inter-arrival time. The objective is to minimize weighted sum of vans fixed cost and travel cost. With FHC data, we can achieve cost reduction of more than $12,000 per month.

2 - Impact of Time Window Policies on Supply Chain Costs

Arpan Rijal, Erasmus University, Rotterdam, Netherlands, rijal@rsm.nl, Marco Bijvank, René De Koster

Sustainability driven time window policies have significant impact on secondary transportation cost for retailers. In this work, we reassess time window policies' impact more holistically. A joint approach that considers warehouse operations and transport planning can mitigate the negative financial impact of time window policies for retailers.

3 - Layout Design for the Future Container Terminals

Amir Gharehgozli, California State University Northridge, Northridge, CA, 91330, United States, Nima Zaerpour, Rene B.M. De Koster

Container terminals play an important role in transporting containerized goods in global supply chains. The number of containers handled in container terminals has increased astronomically. To accommodate and handle the increasing number of containers entering and leaving container terminals, their layout has seen several changes in the past decades. New layouts and designs require smaller footprint and ensure faster, cheaper, and more efficient transfer of containers. This paper studies the transition of layout design from traditional to automated and future container terminals.

4 - Dynamic Relocation of Vehicles and Staff for a One-Way-Car-Sharing Service

Ricardo Giesen, Pontificia Universidad Catolica de Chile, Santiago, Chile, giesen@ing.puc.cl, Diego Strobl, Mathias A. Klapp

Many Car-Sharing (CS) companies operate one-way car-sharing (OWCS) services, which pose many operational challenges. In particular, due to imbalances in demand patterns, some stations receive more departures than arrivals and others the opposite, so if cars are not relocated, some arriving customers will not find cars available at their origin station, or they might not find a place where to park at their desired destination. In this work, we formulated a dynamic optimization model to jointly relocate cars and staff, and proposed different real-time operational strategies. These strategies were tested in different scenarios and one instance with real data from the OWCS AWTO in Santiago, Chile.

5 - Multiobjective Team Orienteering Problem with Time Windows for Energizing Microgrids with Electric Vehicles and Hybrid Electric Vehicle During Natural Disaster Sabotage

Darweesh E. Salamah, PhD. Student, Mississippi State University, Mississippi State, MS, United States, darweesh.salamah@gmail.com, Mahdi Fathi, Mohammad Marufuzzaman

We study the routing and scheduling of power delivery until the arrival of relief in disaster management. And we introduce a new energizing for on-demand energy sharing locations based on EV/HEV during the disaster and post-disaster relief. We consider multiple profits from different aspects associated with each on-demand energy location (ODEL) for each EV/HEV owners. We formulate energizing microgrids with EVs/HEVs during natural disaster problem MOTOPTW to find the set of Pareto optimal solutions to support managers to make decisions. Moreover, we apply a multi-objective evolutionary algorithm based on decomposition and constraint programming (CPMOEA/D) for MOTOPTW optimization.

■ Poster

CC-608 Foyer

Railway Application Poster Session

Sponsored: Railway Applications

Sponsored Session

Chair: Kiran Chahar, Atlanta, GA, 30309, United States

1 - Railway Applications Society Poster Session

Kiran Chahar, NS Corp, 1200 Peachtree St Ne, Atlanta, GA, 30309, United States

The RAS poster session provides an interactive way to share knowledge and state-of-the-art research in railroad applications. Poster presenters will have the opportunity to show case research or projects that are at early stages of development, and benefit from the interactive critique, suggestions, and encouragement from colleagues working in the area of railroad business analytics and optimization.

■ TC40

CC- Room 609

Embracing Non-smoothness and Non-convexity in Statistical Learning

Sponsored: Optimization/Nonlinear Programming

Sponsored Session

Chair: Yudong Chen, Cornell University, Ithaca, NY, 14853, United States

1 - Inference and Uncertainty Quantification for Noisy Matrix Completion

Yuxin Chen, Princeton University, Princeton, NJ, United States, Jianqing Fan, Cong Ma, Yuling Yan

Noisy matrix completion aims at estimating a low-rank matrix given only partial and corrupted entries. Despite substantial progress in designing efficient estimation algorithms, it remains largely unclear how to assess the uncertainty of the obtained estimates. We develop a simple procedure to compensate for the bias of the widely used convex and nonconvex estimators. The resulting de-biased estimators admit nearly precise non-asymptotic distributional characterizations, which enable optimal construction of confidence intervals for, say, the missing entries. As a byproduct, our de-biased estimators provably achieve full statistical efficiency.

2 - When Nonconvexity Meets Nonsmoothness

Ju Sun, Stanford University, Stanford, CA, United States, sunju@stanford.edu

Most applied problems we encounter can be naturally written as nonconvex optimization, which in theory is hard to solve globally. In practice, however, simple methods often work surprisingly well in finding high-quality solutions. In this talk, I will describe recent efforts in bridging the mysterious theory-practice gap. I will highlight a family of smooth nonconvex problems that can be solved to global optimality using simple methods. The discovery does not cover nonsmooth functions, which are increasingly popular in modern applications. I will introduce tools from nonsmooth analysis, and show how nonsmooth, nonconvex problems can also be analyzed and solved in a provable manner.

3 - Low-rank Matrix Recovery with Composite Optimization: Good Conditioning and Rapid Convergence

Damek Davis, Cornell University, ITHACA, NY, 14850, United States, Yudong Chen, Dmitriy Drusvyatskiy, Lijun Ding, Vasilis Charisopoulos, Mateo Diaz

The task of recovering a low-rank matrix from its noisy linear measurements plays a central role in computational science. Smooth formulations of the problem often exhibit an undesirable phenomenon: the condition number, classically defined, scales poorly with the dimension of the ambient space. In contrast, we here show that in a variety of concrete circumstances, nonsmooth penalty formulations do not suffer from the same type of ill-conditioning. Consequently, standard algorithms for nonsmooth optimization, such as subgradient and prox-linear methods, converge at a rapid dimension-independent rate when initialized within constant relative error of the solution.

4 - Large Scale Machine Learning via Gradient Sketching

Amirali Aghazadeh, Stanford University, Stanford, CA, United States, amiralia@stanford.edu

Feature selection is an important challenge in large-scale machine learning. Recently the explosion in the size and dimensionality of real-world datasets has posed a severe challenge to standard feature selection algorithms. Today, it is not uncommon for datasets to have billions of dimensions. At such scale, even storing the feature vector is impossible. In this talk, I will present MISSION, a novel framework for ultra large-scale feature selection that performs stochastic gradient descent while maintaining an efficient representation of the features in memory using a Count-Sketch data structure.

■ TC41

CC- Room 610

Network-Based Analytics and Decision-Making

Sponsored: Optimization/Network Optimization

Sponsored Session

Chair: Foad Mahdavi

1 - Most Closeness-Central Clique Problem

Farzaneh Nasirian, UMass Boston-College of Management, Boston, MA, United States, farzaneh.nasirian001@umb.edu, Foad Mahdavi Pajouh, Balabhaskar Balasundaram

This talk addresses the most closeness-central clique problem in which we are interested in detecting the most accessible clique in a graph. We use two metrics of maximum and total distance to a clique for measuring its accessibility resulting in two variants of the most closeness-central clique problem. For each of these two problems, we address the computational complexity, develop a new mixed 0-1 integer programming formulation, and propose the first combinatorial branch-and-bound algorithm. The computational performance of these exact algorithms is studied on a test-bed of real-life instances.

2 - The Most Degree-central Clique Problem

Haonan Zhong, University of Massachusetts-Boston, Boston, MA, 02188, United States, Foad Mahdavi Pajouh, Oleg A. Prokopyev

The most degree-central clique problem is to find a clique of maximum degree centrality in a graph. We addressed the computational complexity of this problem and proposed a series of theoretical foundations to build a combinatorial branch and bound algorithm for its solution. The performance of our proposed algorithm is tested on real-life networks and random graphs.

3 - The Longest Induced Path Problem: Formulations and Extensions.

Dmytro Matsypura, University of Sydney, Sydney, Australia, dmytro.matsypura@sydney.edu.au, Alexander Veremyev, Oleg A. Prokopyev

The longest induced path problem is defined as the problem of finding a subset of vertices of the largest cardinality such that the induced subgraph is a simple path. In contrast to the polynomially computable graph diameter, this problem is NP-hard. In this talk, we focus on exact and heuristic solution approaches for the problem and its generalisations. We conduct computational experiments to evaluate the performance of the proposed solution methods.

4 - A Network Optimization Approach for Flood Risk Mitigation in Coastal Cities Facing Climate-change-induced Sea Level Rise

Donald J. Jenkins, University of Massachusetts-Boston, Boston, MA, United States, Donald.Jenkins001@umb.edu, Foad Mahdavi Pajouh, Paul Kirshen

Incomplete climate change knowledge is presenting decision-makers in coastal cities with challenges to protect their cities in a deeply uncertain situation. This research extends existing flood cost-benefit optimization research by modeling a coastal region lacking an existing flood mitigation infrastructure with an at-risk network grid to evaluate optimal cost-benefit strategies. Expected flood costs are included using a loss function that samples a range of sea level scenarios, while investment costs are for overall infrastructure development. The problem is modeled as a large-scale mathematical program that optimizes for the minimal overall expected costs.

5 - An Integer Programming Formulation of the Key Management Problem in Wireless Sensor Networks

Maciej Rysz, Miami University, Oxford, OH, 32578, United States, Guanglin Xu, Alexander Semenov

With the advent of modern communications systems, much attention has been put on developing methods for securely transferring information between constituents of wireless sensor networks. To this effect, we introduce a mathematical programming formulation for the key management problem, which broadly serves as a mechanism for encrypting communications in networks. In particular, an integer programming model of the q-Composite scheme is proposed and utilized to distribute keys among nodes of a network. Numerical experiments demonstrating the effectiveness of the proposed model are conducted.

■ TC42

CC- Room 611

Graph Algorithms and Applications II

Sponsored: Optimization/Network Optimization

Sponsored Session

Chair: Golshan Madraki

1 - Heuristics for a Nested Cluster Ratio Cut

Victoria Ellison, Duke University, Durham, NC, 27705, United States, victoria.ellison@duke.edu

Building upon the strengths of the minimum cluster ratio cut problem and hierarchical clustering algorithms, we propose an optimization-based divisive hierarchical clustering algorithm for networks. This algorithm uses a proposed extension of the cluster ratio cut. Introducing a parametric linear programming based heuristic for this algorithm, we compare the utility of our proposed algorithm to that of the minimum nested cluster ratio cut and an iterative application of the minimum cluster ratio cut when applied to gene expression co-association networks.

2 - Finding the Length of the Longest Path in Perturbed Directed Acyclic Graph

Golshan Madraki, Assistant Professor, Clarkson University, Potsdam, NY, 13617, United States, gmadraki@clarkson.edu

This research proposes an efficient algorithm called the Improved Structural Perturbation Algorithm (ISPA) to find the length of the longest path in a structurally perturbed Directed Acyclic Graphs (DAG) where several edges are simultaneously deleted and added. ISPA can update all the length of the affected nodes through a single pass. The mathematical prove for ISPA is provided. The application of ISPA is transformative to problems which can be presented by a structurally perturbed DAG. To illustrate the application of this paper, ISPA is used in the scheduling problem.

3 - Network Optimization Model for Intermodal Empty Railcars Relocation

Juliana Arango, Clemson University, Clemson, SC, United States, arangoc@g.clemson.edu

Given unbalanced supply and demand for empty railcars in the hubs on the intermodal railroad network, the need for empty railcars repositioning is inevitable. Every week hubs request inbound and outbound empty trains for specific dates and times to manage this unbalance. Our objective is to satisfy the maximum number of these request at a minimum cost, considering traveling times between location, availability of empty railcars, and the capacity of nearby storage locations that can be used for holding empty sets. To do so, we formulated a capacitated multi-commodity network flow model.

4 - Network Interdiction with Asymmetric Cost Uncertainty

Di H. Nguyen, PhD Student, Clemson University, Clemson, SC, 29670, United States, din@clemson.edu, Cole Smith

We study a network game between a leader and a follower having opposing objectives. The follower aims to travel from source to sink incurring the least amount of cost possible. The leader's goal is to increase the expected value of the shortest-path cost. In this game, the leader will inflict attacks on some arcs in the network, incurring extra costs on a set of arcs. In this problem, the leader only knows the cost distributions, not each arc's exact value. The follower, after observing the attacks made on the network, obtains perfect information and traverses using a least cost path.

■ TC43

CC- Room 612

Decomposition Methods in Stochastic Programming

Sponsored: Computing

Sponsored Session

Chair: Cheng Guo, University of Toronto, Toronto, ON, M5T 1K5, Canada

1 - Logic-based Benders Decomposition and Binary Decision Diagram Based Approaches for Stochastic Distributed Operating Room Scheduling

Cheng Guo, University of Toronto, Toronto, ON, M5T 1K5, Canada, cguo@mie.utoronto.ca, Merve Bodur, Dionne Aleman, David Urbach

The distributed operating room (OR) scheduling problem aims to find an assignment of surgeries to ORs across collaborating hospitals that share their waiting lists and ORs. We propose a stochastic extension of this problem where surgery durations are considered to be uncertain. In order to solve the stochastic model, we develop an enhanced decomposition approach that utilizes logic-based Benders cuts and binary decision diagram based cuts. Our computational experiments on a real dataset illustrate that the stochastic formulation generates robust schedules, and that our algorithm improves the computational efficiency.

2 - A Logic-based Benders Decomposition Algorithm for Two-stage Stochastic Planning and Scheduling Problem

Ozgun Elci, Carnegie Mellon University, Tepper School of Business, Pittsburgh, PA, 15217, United States, oelci@andrew.cmu.edu, John Hooker

We focus on two-stage stochastic planning and scheduling problems (SPSP). We treat the scheduling decisions as recourse decisions since they are made after the uncertainty is revealed. We develop an exact logic-based Benders decomposition (LBBD) algorithm and benchmark it against an integer programming solver and the integer L-Shaped method. Our results show the effectiveness of our LBBD algorithm. We provide insight as to why the integer L-shaped method fails to perform well in solving the instances of SPSP. Our study exemplifies the importance of exploiting problem structure and the use of decomposition-based hybrid methods in solving two-stage stochastic programs with integer recourse.

3 - Stochastic Task Scheduling with Heterogeneous Agents

Carlos Henrique Cardonha, Research Staff Member, IBM Research, Sao Paulo, 04007-005, Brazil, carlos.cardonha@gmail.com, Andre Augusto Cire

We investigate a variation of the machine scheduling problem motivated by an application on an information technology service line, where tasks have release times and due dates; also, processing times are uncertain and depend on the seniority level of the assigned agents. The proposed solution strategy consists of a logic-based Benders decomposition which uses a stochastic variant of sequencing decision diagrams to minimize expected delay costs. We discuss numerical results on a real-world dataset comparing our algorithm with scheduling algorithms and policies used in practice.

4 - Adaptive Partition-based Stochastic Dual Dynamic Programming Algorithms for Multistage Stochastic Linear Programs

Murwan Siddig, Clemson University, Clemson, SC, 29634, United States, msiddig@g.clemson.edu, Yongjia Song

We extend the adaptive partition-based approach for solving two-stage stochastic programs with fixed recourse to the multistage setting. The proposed algorithm integrates the adaptive partition-based strategy with a popular approach for solving multistage stochastic programs, Stochastic Dual Dynamic Programming (SDDP), via different tree-traversal strategies in order to enhance its computational efficiency. Our numerical experiments on a hydro-thermal power generation planning problem show the effectiveness of the proposed approach.

■ TC44

CC- Room 613

Computational Aspects of Multistage Stochastic Programming

Sponsored: Computing

Sponsored Session

Chair: Harsha Gangammanavar, Southern Methodist University, Dallas, TX, 75275, United States

1 - Sequential Decision Making Affected by Partially Observed Exogenous Forces

Reid Bishop, PhD Candidate, Georgia Institute of Technology, Atlanta, GA, United States, rrb@gatech.edu, Chip White

We consider a class of sequential decision-making problems under uncertainty with multiple levels of effects — a partially observed, exogenous modulation process that affects the dynamics of a completely observed, controllable state process. We model this broad class of problems as a specially structured partially observed Markov decision process (POMDP) and call it the modulated POMDP or M-POMDP. The M-POMDP has many application areas, from inventory control to healthcare systems to dynamic pricing. We show that the M-POMDP inherits value function and optimal policy function structure from its completely observed MDP analog and allows for specialized approximate solution procedures.

2 - Dynamic Freight Routing for Less-than-truckload Carriers under Demand Uncertainty

Ahmad Baubaid, Georgia Institute of Technology, Atlanta, GA, United States, Natashia Boland, Martin Savelsbergh

Less-than-truckload (LTL) carriers consolidate the freight of multiple shippers by routing shipments through a number of intermediate terminals on their way from origins to destinations. Each day, carriers pick up new shipments whose origins, destinations, deadlines, and quantities are unknown beforehand. Carriers make daily routing and consolidation decisions for all on-hand shipments while taking into account the future impacts of those decisions. We formulate this problem as a Markov Decision Process and discuss the use of the computational methods of Approximate Dynamic Programming to solve large instances which are intractable using exact methods due to the curse of dimensionality.

3 - A Lagrangian Dual Decision Rule Approach to Multistage Stochastic Service System Scheduling

Merve Bodur, University of Toronto, Toronto, ON, M5S 3G8, Canada, bodur@mie.utoronto.ca, Maryam Daryalal

Multistage stochastic programs can be approximated by restricting policies to follow decision rules. In this talk, we first review the recently introduced Lagrangian dual decision rules (LDDRs) for multistage stochastic integer programs (MSSIPs). Then, we propose an MSSIP model for the integrated staffing and scheduling problem for service systems, and apply the LDDR approach to get feasible policies. We provide computational results evaluating the performance of the discussed MSSIP framework in this setting and compare our MSSIP model with an existing two-stage approximation.

4 - Stochastic Dynamic Linear Programming: A Sequential Sampling-based Multistage Stochastic Programming Algorithm

Harsha Gangammanavar, Southern Methodist University, Department of EMIS, Dallas, TX, 75275, United States, harsha@smu.edu, Suvrajeet Sen

We present a sequential sampling approach for multistage stochastic linear programming problems that we refer to as the stochastic dynamic linear programming (SDLP) algorithm. Our approach uses samples that increase in size during the course of the algorithm to construct statistical estimates of the value functions. The algorithm uses regularization at non-terminal stages and a piecewise-affine solution discovery scheme to identify incumbent solutions. The SDLP algorithm is shown to provide asymptotically convergent value functions and an optimal policy, with probability one.

■ TC45

CC- Room 614

Methods for Large Scale, Nonlinear and Stochastic Optimization – I

Sponsored: Optimization/Nonlinear Programming

Sponsored Session

Chair: Albert Berahas

1 - Trust-Region Methods for the Derivative-Free Optimization of Nonsmooth Black-Box Functions

Luis Nunes Vicente, Lehigh University, Departamento de Matematica, Bethlehem, PA, 3000, United States

We present for the first time a derivative-free trust-region method for black-box type functions, without assuming any access to (generalized) derivatives or any knowledge about the analytical origin of the nonsmoothness. We propose a trust-region model that is the sum of a max-linear term with a quadratic one so that the function nonsmoothness and possible smoothness can be properly captured. The method enjoys global convergence properties provided the vectors randomly generated for the max-linear term are asymptotically dense in the unit sphere. The numerical results reported demonstrate that our approach is both efficient and robust for nonsmooth unconstrained optimization problems.

2 - Dingo: Distributed Newton-type Method for Gradient-norm Optimization

Fred Roosta, University of Queensland, St. Lucia, 4067, Australia

For optimization of a sum of functions in distributed computing environment, we present a communication efficient Newton-type algorithm that enjoys a variety of advantages. Our algorithm, DINGO, does not impose any specific form on the underlying functions, and its application range extends beyond convexity. Also, the distribution of the data across the computing environment can be arbitrary. Further, the underlying sub-problems of DINGO are simple linear least-squares. Lastly, DINGO involves a few hyper-parameters that are easy to tune. Moreover, DINGO is not sensitive to its hyper-parameters in that a strict reduction in the gradient norm is guaranteed, regardless of the hyper-parameters.

3 - Second Order Stochastic Trust Region Algorithm

Rui Shi, Lehigh University, Lehigh University, Bethlehem, PA, United States, rus415@lehigh.edu

In this talk, we present a new second order stochastic trust region method for solving stochastic and finite-sum minimization problems. This is an extension for our previous work 'TRish' where normalized steps are taken in a controlled manner. While TRish only incorporate stochastic gradient estimate into the algorithm, the new method include stochastic hessian approximation that may help generate a better descent direction. We show that the second order stochastic trust region method has the same type of convergence result with TRish. We also present numerical results showing that the new method has excellent performance when solving convex and nonconvex machine learning test problems.

4 - Nonlinear Acceleration of Primal-Dual Methods

Raghu Bollapragada, Northwestern University, Evanston, IL, 60201, United States, raghu.bollapragada@u.northwestern.edu, Damien Scieur, Alexandre d'Aspremont

In this talk, we present convergence acceleration schemes for primal-dual methods such as Chambolle-Pock. The extrapolated solution is written as a nonlinear average of the iterates produced by the original optimization algorithm where the weights are computed via a simple linear system. Our analysis of Regularized Nonlinear Acceleration, aka Anderson acceleration, does not need the underlying fixed-point operator to be symmetric. We use Crouzeix's conjecture to show that acceleration is controlled by the solution of a Chebyshev problem on the numerical range of a non-symmetric operator. Numerical experiments are detailed on image processing and logistic regression problems.

■ TC46

CC- Room 615

Joint Session TSL/ITS/Practice Curated: Planning and Operations of Electric Tranportation Systems

Sponsored: Transportation Science & Logistics/Intelligent Transportation Systems (ITS)

Sponsored Session

Chair: Mertcan Yetkin, Lehigh University, Lehigh, Bethlehem, PA, United States

1 - An Optimization Framework of National Corridor Charging Infrastructure Planning Considering Heterogeneous Travelers

Fei Xie, Oak Ridge National Lab, Knoxville, TN, United States, xief@ornl.gov, Zhenhong Lin

We introduce a multi-stage optimization framework that optimizes national inter-city public charging station expansion (new location and capacity increase) along the U.S. national interstate highway corridors. The framework has capability of modeling impacts of heterogeneity (e.g., home charging availability) in travel behaviors. Trade-offs in energy and mobility measures, such as total electric vehicle miles traveled, are evaluated with different charging and vehicle technologies.

2 - Dynamic Customer Allocation and Charging Policies for Shared Autonomous Electric Vehicles

Yuxuan Dong, University of Science and Technology of China, Hefei, China, René de Koster, Debjit Roy, Yugang Yu

Multiple platforms exist for vehicle sharing in different countries. In the future, they will be unmanned, autonomous, and electrical. In such an autonomous electric vehicle sharing service systems, the platforms need to decide which vehicle should pick up which type of customer, and when vehicles should recharge based remaining battery level. We model this system as a semi-open queueing network with multiple synchronization stations and propose dynamic customer allocation and charging policies to control the vehicles.

3 - Co-optimizing the Smart Grid and Electric Public Transit System

Mertcan Yetkin, Lehigh University, Bethlehem, PA, United States, mey316@lehigh.edu, Brandon Augustino, Lawrence V. Snyder, Alberto J. Lamadrid

We consider electric public transportation buses in an urban area, which can provide ancillary services to the smart grid during off-schedule times. In particular, we consider a multiperiod optimal power flow (OPF) problem that also decides the optimal charging/discharging times and locations for each bus. In doing so, the transit authority and the ISO co-optimize the power system to minimize the total operational cost of the grid, while ensuring that the buses are fully charged before starting their routes on the next day. We demonstrate the capabilities of the model and the benefit obtained via a coordinated strategy. Our study is motivated by a project with a large transit authority in California.

4 - Dynamic Repositioning in an All-electric Carsharing System

Satya Sarvani Malladi, Postdoc, Technical University of Denmark, Copenhagen, Denmark, samal@dtu.dk, Andrea Papu Carrone, Allan Larsen, Jeppe Rich

Managing a carsharing platform with an all-electric fleet presents unique challenges. In this paper, we investigate solution methods for repositioning cars in a free floating carsharing system that uses electric vehicles. We use a novel basis for the representation of incoming and outgoing trips.

5 - Two-stage Stochastic Choice Modeling Approach for Electric Vehicle Charging Station Network Design in Urban Communities

Seyed Sajjad Fazeli, Dr., Wayne State University, Detroit, MI, United States, Saravanan Venkatachalam, Ratna Babu Chinnam, Alper E. Murat

Electric vehicles (EVs) provide a cleaner alternative that not only reduces greenhouse gas emissions but also improves air quality and reduces noise pollution. The consumer market for Electrical Vehicles is growing very rapidly. Designing a network with adequate capacity and types of public charging stations is a challenge that needs to be addressed to support the current trend in the EV market. In this research, we propose a choice modeling approach embedded in a two-stage stochastic programming model to determine the optimal layout and types of EV supply equipment for a community while considering randomness in demand and drivers' behaviors.

■ TC47

CC- Room 616

Open Source Software for Transportation Systems Research

Sponsored: Transportation Science & Logistics

Sponsored Session

Chair: Changhyun Kwon, University of South Florida, Tampa, FL, 33620, United States

1 - Traffic Equilibrium Tools in the Julia Language: Trafficassignment.jl and Complementarity.jl

Changhyun Kwon, University of South Florida, Tampa, FL, 33620, United States, chkwon@usf.edu

The Julia Language is a computer language designed for computational science and engineering. In this talk, tools and packages available in the Julia Language for optimization and equilibrium problems are introduced. In particular, traffic equilibrium problems are emphasized.

2 - DTALite-virtual Cyber Tracks: Open Source Modeling Framework for Real-time Management of Large Fleets of Self-Driving Cars

Jiawei Lu, Arizona State University, Tempe, AZ, 85281, United States, jiaweil9@asu.edu, Xuesong Zhou

In today's practice, integrated modeling generally functions more like a series of independent activities. We will talk about a data hub as a systematic approach for integrating Analysis Modeling and Simulation (AMS) tools to enable the continuous flow of data which, in turn, allows users to dedicate more time to performing modeling functions such as calibration, alternatives and sensitivity analyses, and performance evaluation.

3 - Open Source Tools for Network Games

Reed Harder, Dartmouth, Hanover, NH, 03755, United States, reed.haseltine.harder.TH@dartmouth.edu

Many transportation networks involve multiple agents making many interrelated decisions in competitive environments. The design and control of such systems can benefit from analysis using tools from game theory. Recent years have seen many theoretical advances in the area of network games, but there are few open source tools for analyzing a broad range of scenarios with potentially continuous, multi-dimensional payoff functions and networked interactions. We present work aimed at filling this gap.

■ TC48

CC- Room 617

Transportation Procurement & Vehicle Routing

Sponsored: Transportation Science & Logistics/Freight Transportation & Logistics

Sponsored Session

Chair: Akang Wang, Carnegie Mellon University, Pittsburgh, PA, 15213, United States

1 - A Branch-and-cut Algorithm for Continuous-time Inventory Routing Problems

Akang Wang, Carnegie Mellon University, Pittsburgh, PA, 15213, United States, akangw@andrew.cmu.edu, Xiandong Li, Chrysanthos Gounaris

The Inventory Routing Problem integrates inventory management, vehicle routing and delivery-scheduling decisions, and is thus of great importance for a multitude of industrial applications. In this talk, we focus on the Continuous-time Inventory Routing Problems (CIRP), where the inventory level is managed in continuous time. We propose a branch-and-cut approach for solving the CIRP, and we also adapt the well-known rounded capacity inequalities so as to strengthen its linear relaxation. Extensive computational studies are performed on literature benchmark instances and demonstrate the competitiveness of our proposed approach against the state-of-the-art.

2 - Dynamic Transportation Procurement with Demand Visibility

Pol Boada-Collado, Northwestern University, Evanston, IL, United States, boada.pol@u.northwestern.edu, Sunil Chopra, Karen Smilowitz

We investigate the value of short-term demand visibility in the decision process of selecting the optimal transportation procurement, a scenario motivated by industry. We show that having this demand information essentially changes contracting policies by adding more dynamism and, with seasonal demand, information is leveraged by properly coordinating with expected demand shocks (e.g. Black Friday) using tailored strategies.

3 - Inter-city Package Service Flow Planning

Adolfo Rocco, PhD Student, Georgia Institute of Technology, Atlanta, GA, United States, Alan Erera, Martin Savelsbergh

We consider an inter-city service network design problem in which packages need to be routed from their origins to their destinations. The main objective is to find a cost minimizing set of routes such that service time requirements are met and sorting capabilities at hubs are respected. The equipment at a hub implies a maximum number of destinations that the hub can sort to. Packages can be cross-docked to any destination at a hub. We propose a two phase model in which the first phase determines commodity sort paths, i.e., decides where a commodity will be sorted, and the second phase determines commodity cross-dock paths, i.e., decides how a commodity is cross-docked between two consecutive sorts.

4 - An Exact Algorithm for a Two Stage Stochastic Vehicle Routing Problem

Vincentius Cornelis Gerardus Karels, Technical University Eindhoven, Utrecht, Netherlands, Tom Van Woensel, Lucas Petrus Veelenturf

A logistics service provider services a set of customers with different service agreements. A difference here is the time period in which customers make their requests known. When customers of the first time period are planned, they require information about their driver and an early indication of the arrival time. At this time customers of the second time period are uncertain. Some estimates of this uncertainty exist. Ultimately all customers have to be planned, constrained by the information given to the customers of the first time period. The objective is to formulate a plan such that the costs in vehicles ordered and kilometers driven is minimized. For this problem an exact algorithm is presented.

5 - Estimation of Marginal Cost to Serve Individual Customers

Akang Wang, Carnegie Mellon University, 5000 Forbes Avenue, Doherty Hall, Pittsburgh, PA, 15213, United States, akangw@andrew.cmu.edu, Jeffrey E. Arbogast, Gildas Bonnier, Chrysanthos Gounaris

We focus on the quantification of the marginal distribution cost for serving new individual customers. We approach this problem via a scenario-sampling framework, where each scenario is a Vehicle Routing Problem with Intermediate Replenishment Facilities (VRPIRF). Utilizing the Hoeffding's inequality, we estimate the number of required scenarios that need to be sampled. We then solve each VRPIRF instance via a Branch-Price-and-Cut approach we have developed to this purpose. We demonstrate our approach via extensive computational studies based on classical benchmark instances from the literature.

■ TC49

CC- Room 618

Simulation-based Optimization for Transportation Systems

Sponsored: Transportation Science & Logistics/Urban Transportation Sponsored Session

Chair: Vadim Sokolov, George Mason University, Fairfax, VA, 22030, United States

1 - Dimensionality Reduction for Stochastic Processes

Laura Schultz, George Mason University, Fairfax, VA, 20169, United States

Simulators play a major role in analyzing multi-modal transportation networks. As their complexity increases, optimization becomes an increasingly challenging task. Current calibration procedures often rely on heuristics, rules of thumb, and sometimes on brute-force search. Alternatively, we provide a statistical method which combines a distributed, Gaussian Process Bayesian optimization method with dimensionality reduction techniques and structural improvement. We then demonstrate our framework on the problem of calibrating a multi-modal transportation network of city of Bloomington, Illinois.

2 - Formulation and Solution Approach for Calibrating Activity-based Travel Demand Model-system via Microsimulation

Siyu Chen, Massachusetts Institute of Technology, Cambridge, MA, United States, siyuc@mit.edu, A. Arun Prakash, Carlos Lima De Azevedo, Moshe Emanuel Ben-Akiva

This study formulates the activity-based model-system calibration problem as a simulation-based optimization problem and proposes a stochastic gradient-based solution procedure to solve it. We derive approximate analytical expressions for the gradient of the objective function. Also, the solution procedure relies on microsimulation on mini-batches of the population to calculate aggregate statistics of interest and gradient of the objective function. Finally, we show that the solution procedure outperforms other state-of-the-art purely simulation-based optimization approaches in terms of computational efficiency, stability, and convergence through a real-world application.

3 - A Network-specific Metamodel Approach for Real-time Demand Calibration of Traffic Simulators

Kevin Zhang, Massachusetts Institute of Technology, Cambridge, MA, 02143, United States, Carolina Osorio

We propose a simulation-based optimization algorithm for real-time demand calibration of stochastic traffic simulators. We present a metamodel-based extended Kalman filter approach that combines simulator information with a problem-specific analytical network model. With this method, we aim to identify transportation-relevant solutions with improved performance within a strict computational budget. The approach is validated on a real traffic network; results are presented.

■ TC50

CC- Room 619

Transportation, Rail

Contributed Session

Chair: Nikola Besinovic, Delft University of Technology, Stevinweg 1, Delft, 2600CN, Netherlands

1 - An Approach to Minimize Energy Consumption in Urban Rail Transit Systems

Wenxin Li, Southwest JiaoTong University, Chengdu, China, wenxinli@my.swjtu.edu.cn

This paper proposes an energy-saving operation model for urban railways with real-world speed profiles, to minimize the trains' energy consumption with dwell-time control. Furthermore, considering the complexity of the train energy consumption model, we use calculus to reduce the power of the train energy consumption model. Then, we have suggested an exterior point method to find an appropriate solution for an energy-saving timetable. The practical case study of the Yizhuang urban railway line in Beijing is selected to verify the effectiveness and the energy-saving performance of the proposed model.

2 - Nearly Real-time Object Detection for Railway Track Inspection via a Deep Learning Based Framework

Li Zhuang, City University of Hong Kong, Hong Kong, Hong Kong, Zijun Zhang

Regular inspection of railway components is crucial to guarantee the safety of railway system. Since fasteners, such as bolts and clippers, and tracks are main components in the railway, detection the existence of these items via a deep learning based framework is proposed in this paper. The detection performance of the proposed method has been demonstrated in the experiment.

3 - A Robust Composition Rescheduling Model

Joris Wagenaar, Assistant Professor, Tilburg University, Tilburg, Netherlands, j.c.wagenaar_1@uvt.nl

Our focus is on rescheduling the composition schedule for practical railway applications. Existing models assume the duration of a disruption given at the time of rescheduling. However, in practice the duration of a disruption is uncertain, so in case new information about the duration is available, the composition schedule must be rescheduled again. In case the disruption lasts longer, decisions taken in the past might turn out to be costly.

We propose a model that is able to reschedule the composition schedule in a robust way with respect to the duration of disruption. Even more, we are able to give a full robust or semi-robust solution. We will demonstrate that robustness comes at a price.

4 - Rail Transfer Hubs Selection in a Metropolitan Area Using Integrated Multimodal Transits

Xinmei Chen, Eindhoven University of Technology, Eindhoven, Netherlands, Tom van Woensel, Virginie Lurkin, Qiyuan Peng, Qiyuan Peng

With the development to urbanization and the passenger's increasing need for convenient travel, integrating multimodal transits (such as metro with railway) is becoming necessary. A MILP model is built for the selection of the transfer hubs in a metropolitan area by considering the fixed cost for the construction suburban railway facilities and the variable passengers' travel time cost.

5 - Excellence in Innovation and Productivity of Indian Railways: Manufacturing of Rolling Stock in ICF and MCF

Sundaravalli Narayanaswami, Associate Professor, Indian Institute of Management Ahmedabad, Ahmedabad, India, sundaravallin@iima.ac.in, Swayambhu Arya

Indian Railways (IR) has not been able to meet with the growing demands for good transport services. An aspect to highlight is dated transport infrastructure which is detrimental. A major and recent bootstrap attempt of IR has been through the two rolling stock manufacturing units: Integral Coach Factory (ICF) and Modern Coach Factory (MCF). ICF manufactured the Vande Bharat Express, a semi-high speed, low-cost, driverless train in a record 18 months. MCF is technologically advanced and they demonstrated a 100% increase in the number of units manufactured annually. We present the transformations that these units have gone through in recent years and the subsequent enhanced credibility of IR.

6 - Integrated Train and Passenger Disruption Management: Simulation-based Optimization Approach

Nikola Besinovic, Delft University of Technology, Delft, Netherlands, n.besinovic@tudelft.nl

Urban railway transit systems in big cities observe increasing occurrences of infrastructure failures which may cause severe disruptions. In this research, we propose a new integrated disruption management methodology for automatically rescheduling trains and controlling passenger flows. Our simulation-based optimization framework incorporates train management decisions with controlling stations and adjusting flows of passengers and aims to minimize total system costs. We test our approach on real-life cases of Beijing metro and discover dependencies between control measures. Our goal is developing solutions that will lead to future decision support systems for railway dispatchers.

■ TC51

CC- Room 620

Joint Session AAS/TSL Air: Analytics in AAS Management

Sponsored: Aviation Applications

Sponsored Session

Chair: Xiaojia Guo, University College London, London, WC1N 1AS, United Kingdom

1 - Air Passenger Demand Forecasting Using Deep Learning Methods

Nahid Jafari, Assistant Professor, SUNY, Farmingdale, New York City, NY, United States, jnahid@hotmail.com

Demand for air travel is essentially driven by economic and tourism activities. The economic recessions decreases demand for leisure and business travel, consequently, demand for air transport. Air transport demand forecasting is receiving increasing attention, especially because of intrinsic difficulties and practical applications. The forecast of the air passenger demand over time can be analyzed as time series forecasting in which it has a complex behavior due to their irregularity, high volatility and seasonality. We examine various deep learning methods to predict the air passenger demand of the U.S. domestic airlines. We implement the models with Keras, the Python deep learning library.

2 - Forecasting Airport Transfer Passenger Flow Using Real-time Data and Machine Learning

Xiaojia Guo, University College London, International Hall, Lansdowne Terrace, London, WC1N 1AS, United Kingdom, x.guo.11@ucl.ac.uk, Yael Grushka-Cockayne, Bert De Reyck

We develop a two-phased predictive system that produces forecasts of transfer passenger flows. In the first phase, the system predicts the entire distribution of passengers' connection times. In the second phase, the system samples from the distribution of individual connection times and produces distributional forecasts for the number of passengers arriving at the immigration and security areas. Theoretically, we show that point forecasts of passenger flows generated by the two-phased approach are unbiased, and that distributional forecasts can be well-calibrated when adding correlation as a tuning parameter. Our two-phased approach is shown to be more accurate when compared to benchmarks.

3 - Boost Ancillary Product Upsell Prospects by Using Airline Clickstream Data

Cheng-Lung Wu, Associate Professor, UNSW Australia, School of Aviation, Kensington, NSW 2052, Australia, Jacob Wong

We used airline clickstream data to develop a predictive model to predict ancillary product upsell opportunities for potential customers. We focused our modelling on frequent flyer members of an airline from which rich frequent flyer data could be utilised for model development. To test the model, we built a simulated airline booking website with the Python model integrated at the back-end for real-time prediction and choice experiments. Results show that it is harder to predict ticket purchase with click data alone but easier for ancillary products. The model could reasonably predict return visits to the airline website and this prediction is crucial for customer engagement in airline e-commerce.

4 - Collaborative Decision-making and the Airport Operations Centre in Europe

Floris Herrema, EUROCONTROL, Brussel, Belgium, floris.herrema@eurocontrol.int

Improving airport performance is at the heart of the SESAR's Airport Operations Centre (APOC) solution. In this study, we review APOC roles and responsibilities, identify the key APOC processes that could be enhanced by data-driven predictions and machine learning techniques, and demonstrate a case study of how shared data and advanced analytics can be used to make predictions of passengers' connection times. In the case study, a regression tree model is fitted to a large training set with 3.7 million passenger records. This predictive model is applied to generate forecasts of each passenger's connection time and the passenger flows during an eight-hour live trial.

5 - Gate Assignment Optimization with the Consideration of Airport Retailing

Tulay Flamand, Colorado School of Mines, Division of Economics and Business, Golden, CO, 80401, United States, tulayvarol@gmail.com, Heng Chen

We address a gate assignment problem by considering its impact on the revenue of airport retailers. We propose a mixed-integer programming model that assigns flights to gates in a way that optimizes several objectives, as well as the retail sales. A column generation methodology is used to solve this challenging problem and the experimental results are reported.

■ TC52

CC- Skagit 1

Data-Driven Models and Algorithms

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Mingcheng Wei, University at Buffalo, Buffalo, NY, 14260, United States

1 - Data-driven Dynamic Pricing and Ordering with Perishable Demand Information and Inventory

Yuexing Li, Duke University, Durham, NC, United States, yuexing.li@duke.edu, N. Bora Keskin, Jing-Sheng Jeannette Song

We study joint pricing and inventory decisions for a perishable product in a changing environment. The decision maker does not know inventory perishability rate, demand change-points, or demand parameters before and after the change. We design two data-driven policies to aid decision making for profit maximization and establish their rate optimality. Our policies achieve significantly higher profits relative to the company policy used in practice.

2 - Causal Inference via Matrix Factorization

Xiaojie Mao, Cornell University, New York, NY, United States, xm77@cornell.edu, Madeleine Udell, Nathan Kallus

Valid causal inference usually requires measuring confounders precisely. However, in practice measurements of confounders may be noisy and lead to biased causal effect estimates. We propose to reduce the bias by using matrix factorization to infer confounders from a large number of noisy and missing covariates. This flexible and principled framework accommodates diverse data types and enhances many causal inference methods. We bound the error for the induced causal effect estimator and show its consistency in a linear regression setting with Exponential Family Matrix Completion preprocessing. We demonstrate the effectiveness of the our procedure in both synthetic data and real clinical data.

3 - Dynamic Assortment Planning with Changing Contextual Information

Xi Chen, New York University, New York, NY, 10012, United States, xchen3@stern.nyu.edu, Yining Wang, Yuan Zhou

We consider the problem of dynamic assortment planning with changing feature information, and the customers' preferences are modeled by items' feature vectors together with an unknown linear model. We present a dynamic policy for simultaneous learning preference models and maximizing expected revenues, and give the near-optimal regret analysis.

4 - Online Assortment Optimization with High-dimensional Data

Mike Wei, University at Buffalo, Buffalo, NY, 14260, United States, mcwei@buffalo.edu, Xue Wang, Tao Yao

In this study, we consider the online assortment optimization problem with high-dimensional covariates. We propose an online assortment optimization algorithm that combines Lasso and random projection to handle the high-dimensional issue and show that the cumulative regret of this algorithm is upper bound by O(T^(1/2) log d), where d is the covariates dimension and T is the time length.

■ TC53

CC- Skagit 2

Machine Learning and Optimization in RM

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Srikanth Jagabathula, NYU Stern School of Business, New York, NY, 10012, United States

Co-Chair: Ashwin Venkataraman, New York University, Cambridge, MA, 02139, United States

1 - Global Convergence Guarantees for Policy Gradient Methods

Daniel Russo, Columbia University, Kellogg School of Management, New York, NY, 60208, United States

Policy gradients methods are perhaps the most widely used class of reinforcement learning algorithms. Unfortunately, even for simple control problems solvable by classical techniques, policy gradient algorithms face non-convex optimization problems and are widely understood to converge only to local minima. This work identifies structural properties — shared by finite MDPs and several classic control problems — which guarantee that policy gradient objective function has no suboptimal local-minima despite being non-convex. When these conditions are relaxed, our work shows any local minimum is near-optimal, where the error bound depends on the expressive capacity of the policy class.

2 - Applications of Stochastic Bandits for Behavior-aware Recommendations

Theja Tulabandhula, UIC, FF07 Ajanta Vihar, Yelahanka, Chicago, IL, United States, Yunjuan Wang, Priyank Agrawal

We consider two behavioral effects that modulate relevance and revenue while making recommendations sequentially: (a) the users have a latent propensity to act on a recommendation based on its position in a sequence of recommended items, and (b) the users have a latent propensity to act on a recommendation only if it has been shown to them repeatedly. In both settings, the platform wants to simultaneously learn the quality of its recommendations and the corresponding user behavior, while exploiting the information it knows so far to maximize revenue. We explore the applicability of popular bandit algorithms to these settings.

3 - Contextual Bandits with Cross-Learning

Jon Schneider, Google Research, New York, NY, 10018, United States

In the contextual bandits problem, in each round t, a learner observes some context c, chooses some action a to perform, and receives some reward ra,t(c). We study the variant of this problem where the learner also learns the values of ra,t(c') for all other contexts c'. This variant arises in several strategic settings, such as learning how to bid in non-truthful repeated auctions. The best algorithms for the classical contextual bandits problem achieve O(sqrt(CKT)) regret against all stationary policies, where C is the number of contexts, K the number of actions, and T the number of rounds. We demonstrate algorithms for our variant that remove the dependence on C and achieve improved regret bounds.

4 - A General Framework for Regularized Gradient Boosting

Ashwin Venkataraman, UT Dallas, TX, 02139, United States, Srikanth Jagabathula

Gradient boosting is a very popular ensemble learning technique to improve the performance of many machine learning tasks like classification and regression. However, boosting can suffer from overfitting, especially if the underlying set of base hypotheses is complex. We propose a general framework for regularized gradient boosting that provides a principled way to tackle the overfit issue. We show that the regularized empirical risk minimization problem can be formulated as a constrained convex program, and by leveraging the Frank-Wolfe algorithm to solve it, we recover one base hypothesis in each iteration, resulting in the structure of a standard boosting algorithm.

■ TC54

CC- Skagit 3

Online Algorithms for Matching and Assortments

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Vineet Goyal, Columbia University, New York, NY, 10027, United States

1 - Matching with Stochastic Departures

Ali Aouad, London Business School, London, NW64TG, United Kingdom, aaouad@london.edu, Omer Saritac

Dynamic matching markets are subject to a fundamental tradeoff between the latency and the quality of the matches. In this context, we study a stochastic matching optimization model, with long-lived agents whose departure times are uncertain. We present simple non-adaptive matching policies, backed by worst-case performance guarantees on a large class of graphs. By implementing these policies on real data sets, we provide insights about the cost efficiency frontier of ridesharing platforms.

2 - Assortment Auctions: A Myersonian Characterization for Markov Chain Based Choice Models

Will Ma, Columbia University, New York, NY, 02139, United States

We introduce assortment auctions, where each buyer reports a ranking preference to a platform, and is then sold a product by a truthful mechanism. We compute the revenue-optimal mechanism under Markov Chain choice models and show it is Myersonian, in that allocations are made using virtual valuations, which are assigned to each buyer based on her ranking and Markov chain. We show that this structure fails for general ranking distributions. Our result generalizes both Myerson's optimal auction and assortment optimization with Markov chain models. We apply it to online assortment problems.

3 - Online Matching with Reusable Resources: Beating 1/2

Rajan Udwani, Columbia University, New York, NY, United States, Vineet Goyal, Garud N. Iyengar

We consider the problem of online matching with reusable resources. This setting arises commonly in many applications including cloud computing, physical storage, make-to-order service and other sharing economy applications. Previously, Gong et al. (2019) showed that the greedy policy is 1/2 competitive for this problem. We give an algorithm with competitive ratio better than 1/2.

4 - On the Disclosure of Promotion Value in Platforms with Learning Sellers

Gregory Macnamara, Stanford University, Stanford, CA, United States, Yonatan Gur, Daniela Saban

We consider the problem of an online platform that hosts third-party sellers and seeks to maximize consumer surplus. The platform cannot set prices but influences a seller's pricing policy through its own promotion policy (e.g. by giving a seller a prominent position on the webpage) and through the information it communicates to sellers about the value of promotions. The platform's information design problem is complicated by the fact that sellers can learn from past sales observations and update prices dynamically. In this setting, we characterize the maximum long-run average consumer surplus, and platform information and promotion policies that achieve it.

■ TC55

CC- Skagit 4

Revenue Management Models for Pricing and System Control

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: John G Turner, University of California-Irvine, Irvine, CA, 92697-3125, United States

1 - Markov Chain Models for Controlling the Exposure Frequency Distribution of Online Advertising

Ali Hojjat, University of New Hampshire, 10 Garrison Ave., Durham, NH, 03824, United States, ali.hojjat@unh.edu, John G. Turner

Recent trends in online advertising show that explicit reach and frequencyspecifications are preferred over aggregate impression or budget goals. Wemodel a user's ad exposure as a controlled Markovian process. Then we derive a closed-form ad serving policy that can achieve a desired frequency distribution for an online ad campaign and characterize the necessary and sufficient conditions for such policy to exist. Extensions of our framework to multi-advertiser and multi-audience-segment settings are also presented.

2 - Analysis of Pricing Mechanisms in Resource Exchange Economy

Ali Hassanzadeh Kalshani, The Paul Merage School of Business, UC Irvine, 1723 Verona Place, Irvine, CA, 92617, United States, ahassan2@uci.edu, John G. Turner, Luyi Gui

In many real-world settings where resources are shared, decentralized agents (e.g., individual competing firms) maximize their profits, and in so doing, choose to use an amount of a resource. Motivated by a desire to understand the theoretical and structural underpinnings of what makes coordinating decentralized agents hard or easy, we study the effectiveness of different pricing mechanisms. In particular, we analyze nonlinear prices as well as prices obtained by Dantzig-Wolfe decomposition algorithm.

3 - Revenue Management of Observable Express Queues with Customer Choice

Jiaqi Zhou, PhD Candidate, University of Maryland, Robert H. Smith School of Business, College Park, MD, 20742, United States, emily719@math.umd.edu, Ilya O. Ryzhov

We consider a stylized model motivated by paid express lanes on highways: two parallel, observable queues, one of which has a faster service rate, but charges a fee to join. Customer choice is based on observed queue lengths at the time of arrival, subject to random shocks as in the MNL and exponomial choice models. We characterize the equilibrium of the system, show how the structure of the equilibrium changes depending on the entry fee, and demonstrate that the revenue function can be nonconcave.

4 - Asymmetric Pricing and Replenishment Controls for Substitutable Products

Oben Ceryan, City, University of London, 106 Bunhill Row, Cass Business School, London, EC1 Y. 8TZ, United Kingdom, Oben.Ceryan@city.ac.uk

We study settings in which a firm offering substitutable products may face restrictions in its ability to either replenish or adjust the prices of some of its products, resulting in asymmetries in the pricing and replenishment controls available for each product. We characterize the structure of the optimal pricing and replenishment policies under this asymmetric control setting. Through the insights gained by the optimal policy structure, we also develop an effective heuristic policy.

■ TC56

CC- Skagit 5

Joint Session PSOR/Practice Curated: Healthcare Policy Modeling

Sponsored: Public Sector OR

Sponsored Session

Chair: Yueran Zhuo, PhD, Massachusetts General Hospital, Harvard Medical School, Boston, MA, United States

Co-Chair: Gizem Nemutlu, PhD, Massachusetts General Hospital, Harvard Medical School, Boston, MA, 02114, United States

1 - Scaling Up HPV Vaccination to Reduce HPV-associated Anal Cancer Incidence: Model-based Predictions

Gizem S. Nemutlu, Postdoctoral Research Fellow, Harvard Medical School and MGH, 8 Kimball Ct Unit 914, Boston, MA, 01803, United States, gnemutlu@mgh.harvard.edu, Jagpreet Chhatwal, Ashish A. Deshmukh, Ryan Suk

Human papillomavirus (HPV)-associated anal cancer is one of the most common cancers in HIV-infected (HIV+) men who have sex with men (MSM). The incidence of HPV-associated anal cancer has continued to increase among HIV+ MSM in the US. HPV vaccination may reverse rising rates; however, vaccination uptake remains low in boys. To our knowledge, no study examined the effect of HPV vaccine on anal cancer incidence. We develop a microsimulation model to address this gap and inform policy makers by evaluating the impact of different vaccination coverage policies on HPV-associated anal cancer incidence trends.

2 - Modeling the Feasibility of Achieving the 2030 Hepatitis C Elimination Targets in the United States

Yueran Zhuo, Harvard University, East Boston, MA, 02128, United States, yzhuo1@mgh.harvard.edu, Jagpreet Chhatwal, Peter Mueller, Qiushi Chen, Tiannan Zhan, Mary Ann Ladd

Hepatitis C virus (HCV) infection is a public health threat in the United States. The availability of highly effective oral direct-acting antivirals (DAAs) has changed the HCV treatment paradigm, offering an unprecedented opportunity to eliminate HCV. We utilize a validated mathematical model to assess temporal trends in hepatitis C disease burden from 2018 to 2040. We aim to investigate if, and under what conditions, HCV elimination is feasible at the state level and in selected subpopulations including state Medicaid beneficiaries and incarcerated individuals. Our analysis also serves as important guideposts to policymakers to determine progress towards HCV elimination at the state level.

3 - Physician Staffing and Shift Scheduling at Emergency Departments with Time Varying Productivity

Alireza Sabouri, Haskayne School of Business, University of Calgary, Calgary, AB, T2N 1N4, Canada, Negar Ganjouhaghighi, Marco Bijvank

We consider the problem of physician staffing and shift scheduling for an emergency department (ED). Patients show up according to a non-homogenous random arrival process and the productivity of physicians varies over time and between physicians. The variable productivity alongside the stochastic nature of arrivals to the healthcare system, create a mismatch between demand and the number of patients that can be served by the scheduled physicians. We propose a stochastic programming formulation for the staffing and shift scheduling problem. Our numerical results based on real data from an ED suggest that our proposed schedules lead to shorter average waiting times and more balanced workload.

■ TC57

CC- Yakima 1

Disaster Operations Management

Sponsored: Public Sector OR

Sponsored Session

Chair: Christopher Zobel, Virginia Tech, Blacksburg, VA, 24061-0235, United States

Co-Chair: Andrew N. Arnette, University of Wyoming, Laramie, WY, 82071-2000, United States

1 - Beneficiary Appointment Scheduling for Delivering Humanitarian Aid in Conflict-affected Regions

Burcu Balcik, Ozyegin University, Industrial Engineering Department, Istanbul, 34794, Turkey, burcu.balcik@ozyegin.edu.tr, Melih Celik, Maria Battarra, Bashar Khoury

Humanitarian agencies manage multiple aid programs to meet the needs of the people in the conflict-affected regions. The final delivery of aid is made by local agencies at the relief service centers. Motivated by the needs of local humanitarian agencies that deliver aid in Syria, we develop mathematical models and heuristic algorithms to support beneficiary appointment scheduling decisions at the local service centers. We discuss our findings and insights obtained from the surveys conducted by the local agencies in the conflict-affected area and present how we incorporate the unique challenges of this setting into decision making. We illustrate our methods on a real-world network.

2 - Value Function Approximation for Last-mile Distribution in Humanitarian Relief

Robert A. Cook, Northeastern Illinois University, Chicago, IL, 60646, United States, Racook2@neiu.edu, Emmett J. Lodree

This study describes a Value Function Approximation approach for solving a Markov Decision Problem in which we distribute stochastically-arriving donations to disaster survivors. Donations accumulate over time at collection sites and are periodically transported to a relief center where the donations are distributed to beneficiaries over a finite horizon.

3 - Agent-based Model Simulations of Spontaneous Volunteer Convergence in Disaster Response

Kyle Paret, North Carolina State University, North Carolina, Raleigh, NC, 27519, United States, keparet@ncsu.edu, Maria Esther Mayorga

The use of Spontaneous Volunteers (SVs) is widespread following a disaster such as a hurricane. However, there exists a need to address the implications of the rise in spontaneous volunteering. Management plans and more structured efforts to integrate SVs are necessary for effective disaster response. We develop an Agent-Based model to simulate SV convergence in disaster response. We highlight the effects that information sharing, individual motivation, and integration have on response efforts.

4 - Risk-based Modelling Approach for Post-disaster Sheltering Problem

Duygu Pamukcu, Virginia Tech, Blackburg, VA, 24060, United States, duygu@vt.edu, Andrew N. Arnette, Christopher Zobel

Managing shelter operations during natural disasters requires good understanding of the characteristics of both the hazard event and the affected population. Although reducing the potential risk of disaster is an important concern of relocation, it is not typically regarded as an objective of shelter location-allocation decisions. This study follows a Design Science Research Methodology to provide decision support for sheltering operations and suggests a multi-objective decision-making approach that minimizes evacuation time and disaster risk for more effective management of disaster shelters.

■ TC58

CC- Yakima 2

Human Trafficking and ORMS: A Panel Discussion

Sponsored: Public Sector OR

Sponsored Session

Chair: Kayse Lee Maass, Northeastern University, Boston, MA, 02115, United States

Panelist

Kayse Lee Maass, Northeastern University, 360 Huntington Ave., 334 SN, Boston, MA, 02115, United States, k.maass@northeastern.edu

Dr. Kayse Lee Maass is an Assistant Professor of Industrial Engineering and leads the Operations Research and Social Justice lab at Northeastern University. Her research focuses on optimization models to disrupt human trafficking through prevention, interdiction, and service provision to victim-survivors. Discussion topics include her ongoing research in scaling capacity for increased victim-survivor access to shelter services, interdicting human trafficking networks, and understanding cross-border human trafficking flows, as well as lessons learned in pursuing convergence research.

Panelist

Kezban Yagci Sokat, Northwestern University, Evanston, IL, United States, kezban.yagcisokat@u.northwestern.edu

Dr. Yagci Sokat is an adjunct professor at the Industrial Engineering and Management Sciences Department at Northwestern University, where she received her PhD Dr. Yagci Sokat's research focuses on using mathematical modeling and decision analytics to alleviate human suffering. Her main research interests are human trafficking, humanitarian logistics and healthcare operations. She specializes in integrating limited information in decision making for NGOs and public officials. She pursues multiple human trafficking projects on prevention, identification, response and disruption in collaboration with a variety of groups ranging from victims to law enforcement personnel.

Panelist

Shawn Bhimani, Northeastern University, Boston, MA, 37922, United States, s.bhimani@northeastern.edu

Shawn Bhimani uses econometrics, game theory, and qualitative research to study the supply chain of human trafficking through the lenses of government intervention mechanisms and supply chain disruption. His industry background in supply chain management influences his perspective and research on human trafficking networks. He has worked in consulting, corporate supply chains, research for the U.S. Department of Energy, co-founded a private distribution company, and teaches Supply Chain Management at Northeastern University. He has developed frameworks for catastrophic supply chain disruption and applies them to attack the trafficking networks involved with forced labor.

Panelist

Anna White, University of Michigan, Ann Arbor, MI, United States, agracew@umich.edu

Anna is a second year PhD student at the University of Michigan in the Department of Industrial and Operations Engineering. She is using predictive modeling and data analytics to study human trafficking, with a particular focus on illicit massage parlors as a venue of trafficking. In this panel, she will discuss her perspective on using operations research methods to tackle the problem of human trafficking.

Panelist

Matt Kammer-Kerwick, Research Scientist, The University of Texas at Austin, Austin, TX, 78723, United States, mattkk@ic2.utexas.edu

This talk will discuss ongoing NSF-funded research (CMMI 1838039) which is exploring the use of stochastic games, reinforcement learning algorithms, and agent-based models to assess and develop disruptive interventions for illicit supply chains. Additional discussion topics will include challenges faced in the development and application of operations research models and data analytic methods toward solutions for social, environmental, and and economic justice problems, assessing the scope and prevalence of human trafficking in the State of Texas, and assessing the perceptions and prevalence of interpersonal violence at institutes of higher learning.

■ TC58a

CC- Chelan 1

12:05-12:50 T-Mobile
12:50-1:35 Simio Simulation & Scheduling Software

Vendor Tutorial

1 - From Theory to Practice: Applying O.R. to Change Wireless for the Better

Orcun Molvalioglu, T-Mobile, Seattle, WA, United States

At T-Mobile, we're a vast, complex, evolving business that puts customers first - and we need creative, analytical minds to make sure we're efficient also. In this session, Orcun will illustrate some business questions that we face at T-Mobile, and how we tackle them using Operations Research techniques – for example: • pricing optimization • supply chain logistics • predicting customer churn • optimizing geographic expansion of network and retail stores • call center queueing and routing• media attribution and mix modeling • website and behavioral analytics Come learn how we apply O.R. techniques at T-Mobile, and join our analytical team!

2 - Simulation and Scheduling Software All in One!

Jason Ceresoli, Simio LLC, Lousville, KY, United States

Simio is a premier simulation and scheduling software that allows you to expand traditional benefits of simulation to improve daily operations. In this tutorial, we will demonstrate Simio's 3D rapid modeling capability to effectively solve real problems. Explore how a single tool can be used to not only optimize your system design, but also provide effective planning and scheduling. Come explore the Simio difference and see why so many professional and novice simulationists are changing to Simio.

■ TC59

CC- Chelan 2

Advancements in Spatial and Temporal Data Analytics - I

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Jian Liu, University of Arizona, Tucson, AZ, 85721, United States

Co-Chair: Shyam Ranganathan, Virginia Polytechnic Institute and State University, Blacksburg, VA, 24061, United States

1 - A Marked Point Process Spatio-temporal Model of Wildfire Ignition with a Case Study Using Oregon Data

Farshad Farkhondehmaal, Virginia Polytechnic Institute, Blacksburg, VA, 24061, United States, farshad1@vt.edu, Shyam Ranganathan

Wildfires are disastrous events endangering both people and the environment and these are increasing in number and intensity over the last few decades. Wildfire forecasting is difficult, as ignition in small fields or small timescales are rare events. At the same time, the process is not stationary over larger spatial and temporal units and hence statistical models scale badly. We introduce a a marked point process spatiotemporal model of fire ignition to forecast the ignition at a suitable spatial and temporal resolution. We predict ignition based on the climate variables in each region and ignition cause. We then consider Oregon as a case study and validate our model.

2 - Using a Spatiotemporal Model to Predict Tumor Response to Therapy

Reza Iranzad, University of Arkansas, Fayetteville, AR, 72701, United States, riranzad@email.uark.edu, Xiao Liu, Wanpracha Art Chaovalitwongse, Stephen Bowen, Daniel Hippe, Chunyan Duan, Phawis Thammasorn, Robert Miyaoka, Hubert Vesselle, Paul Kinahan, Ramesh Rengan, Jing Zeng, Shouyi Wang

The aim of this study is to predict the tumor behavior in response to treatment at early and middle stages of treatment. Quantitative assessment was performed based on the amount of F-FDG that the tumor uptakes. For this purpose, a spatiotemporal model alongside different supervised learning algorithms was used to study spatial variation and detect spatiotemporal patterns.

3 - Customers Budgeting Behavior understanding via Temporal Basis Expansion

Yifei Yuan, Google LLC, Mountain View, CA, United States, T om Ferriss

AdWords customers can set and change advertising budgets. It is important to understand budget change behavior, which leads to a more customer-friendly product. To achieve their specific goals, some customers tune their daily budget frequently, providing a rich dataset of time series. Existing temporal decomposition approaches, such as wavelets and Fourier decomposition, do not work well for all customers because of i) heterogeneity in budgeting behavior ii) customer switching between behavior patterns and iii) frequency inconsistency due to variable number of days in each month. Thus, a self-generated basis expansion approach is proposed to better understand customers' budgeting behavior.

4 - Spatiotemporal Analytics on IBM Physical Analytics Integrated Data Repository and Services (PAIRS)

Rui Zhang, PhD, IBM Research, Yorktown Heights, NY, United States, Rui.Zhang@ibm.com, Siyuan Li, Marcus Freitag, Conrad Albrecht, Xiaoyan Shao, Fernando Marianno, Ildar Khabibrakhmanov, Levente Klein

PAIRS is a platform, specifically designed for massive geospatial-temporal data analytics services. Geospatial-temporal data acquisition and preparation can be challenging as there exist vast varieties of data formats and geo-projection methods. These binary file formats are highly inefficient for spatial-temporal analysis. PAIRS has been developed to provide search-friendly ready access to a rich, diverse, and growing catalog of historical and continuously updated geospatial-temporal information. PAIRS is a multi-peta bytes data platform and ingesting multi-tera bytes of data on a daily basis. We will present several spatiotemporal analytics capabilities developed upon PAIRS.

■ TC60

CC- Chelan 4

Data Analytics for Advanced Manufacturing Systems

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Chenang Liu, Blacksburg, VA, 24060, United States

Co-Chair: Wenmeng Tian, Mississippi State University, MS, 39762, United States

1 - A Constrained Signal Decomposition Approach for Side Channel Monitoring of Additive Manufacturing Process

Wenmeng Tian, Mississippi State University, Mississippi State, MS, 39762, United States, tian@ise.msstate.edu, Chenang Liu, Chen Kan

Additive manufacturing (AM) technologies have been widely applied to a large variety of areas. However, how to achieve effective in-situ process monitoring and control for AM still remain challenging. To address this issue, this study proposes a constrained signal decomposition approach to detect unintended process changes with accurate root cause diagnosis using side channel sensing signals. The effectiveness of the proposed method is validated by both simulation and actual AM case studies.

2 - Deep Learning of Variant Geometry in Layerwise Imaging Profiles for Additive Manufacturing Quality Control

Farhad Imani, The Pennsylvania State University, Leonhard Building, State College, PA, 16802, United States, Ruimin Chen, Evan Diewald, Edward Reutzel, Hui Yang

Additive manufacturing (AM) is a new paradigm in the design-driven build of customized products. Nonetheless, mass customization and low volume production make the AM quality assurance extremely challenging. The proposed research is aimed at developing a novel machine learning approach that is focused on variant geometry in each layer of the AM build, namely region of interests, for the characterization and detection of layerwise flaws. A DNN model is designed to learn variant geometry in layerwise imaging profiles and detect fine-grained information of flaws. Experimental results show that the proposed deep learning methodology is highly effective to detect flaws in each layer.

3 - Multivariate Model Calibration in the Absence of Experimental Observations: An Application in Metal Additive Manufacturing

Bing Zhang, Texas A&M University, College Station, TX, 77843, United States, zb19911212@tamu.edu, Mohamad Mahmoudi, Alaa Elwany

Simulation models for additive manufacturing are essential to enable process planning and accelerate qualification and certification of fabricated parts. One important task involves calibrating these models to ensure that predictions are in agreement with experimental observations. In this study, we consider the calibration of a computer simulation model with multiple outputs where experimental observations for one (or more) of the output are expensive to acquire. We present a case study on calibrating an analytical simulation model for new materials development in metal additive manufacturing.

4 - Multiple Signals Monitoring for Quality Control in Additive Manufacturing

Marco Grasso, Politecnico di Milano, Milano, 20156, Italy, marcoluigi.grasso@polimi.it, Bianca Maria Colosimo

In this talk, we describe novel solutions for multi-stream signal data analysis and monitoring for inline detection of defects in powder bed fusion via electron beam melting.

■ TC61

CC- Chelan 5

Joint Session QSR/HAS: Data Analytics in Medical Decision-making

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Devashish Das, University of South Florida, Tampa, FL, 33620, United States

1 - Privacy-preserving Predictive Analysis Across Multiple EHR Databases

Ying Lin, University of Houston, Houston, TX, 77204, United States, ylin58@uh.edu

Predictive analysis across hospitals is challenging due to the concerns on patient privacy and lack of efficient data sharing framework. Contextual embedding models which encode the medical events into vector representations while preserve the contextual dependencies between events have shown promises in predictive analysis without the need to disclose original data. To promote the predictive analysis across hospitals, we developed a novel data sharing framework which integrates the contextual embedding and embedding harmonization. The harmonized embeddings are further used to perform predictive analysis which outperforms the prediction in single data source.

2 - Survfit: Doubly Sparse Rule Ensemble Learning for Survival Data

Ameer Hamza Shakur, University of Washington, Seattle, WA, United States, ahamza@uw.edu, Shuai Huang

A crucial objective in the study of high dimensional medical data is the development of inherently interpretable models which can capture sparse underlying signals while retaining a high predictive accuracy. Rule-based models have been shown to accomplish these objectives. However, conventional rule-learning approaches do not promote variable selection and sparsity among the generated rules. Here we present Survfit, a 'doubly sparse' rule extraction formulation for survival data which induces sparsity in both rules and the variables involved in the rules. We subsequently demonstrate the utility of this model via simulated experiments and a real-world data-set of sepsis.

3 - Statistical Monitoring of Queuing Networks

Yanqing Kuang, University of South Florida, Tampa, FL, 33613, United States, ykuang@mail.usf.edu, Devashish Das

Many service systems can be modeled as queueing networks with multiple service nodes, and their performance are highly influenced by the service rate. In this research, by using the likelihood ratio based cumulative sum(CUSUM) scheme, the simple CUSUM chart, general CUSUM chart and penalized CUSUM chart are proposed to monitor the change of node service rate . Furthermore, the performance of proposed CUSUM charts are compared and evaluated in terms of the average run length (ARL) for detecting the shift through numerical studies. It's demonstrated that the proposed CUSUM charts can effectively detect the shift of the service rate for any node.

4 - Quantifying the Impact of Resuscitation-team Activation in Hospital Emergency Departments

Devashish Das, University of South Florida, Tampa, FL, 33620, United States, Xiaochen Xian, Kalyan Pasupathy, Eric Boie, Mustafa Y. Sir

Hospital emergency department (ED) operations are affected when critically ill or injured patients arrive. Such events often lead to the initiation of specific protocols, referred to as Resuscitation-team Activation (RA) in the ED of a large academic medical center where this study was conducted. RA events lead to the diversion of resources from other patients in the ED to provide care to critically ill patients; therefore it has an impact on the entire ED system. This research presents a data-driven and flexible statistical learning model to quantify the impact of RA on the ED.

■ TC62

CC- Tahoma 1

Data-driven Approaches for Emergency Department Applications

Sponsored: Health Applications

Sponsored Session

Chair: Hyojung Kang, University of Illinois at Urbana-Champaign, Mahomet, IL, 61853, United States

Co-Chair: Kalyan Pasupathy, Mayo Clinic, Rochester, MN, 55905, United States

1 - Analysis of Emergency Department Visits by Frequent Users Using Deep Learning

Hyojung Kang, University of Illinois at Urbana-Champaign, Champaign, IL, 61853, United States, hyokang@illinois.edu, Riordan John

Patients who have recurrent emergency department (ED) visits have been identified as frequent users (FUs). Approximately 21-28% of ED visits are attributable to only 4.5-8% of ED patients. Previous studies on FUs have focused on comparing characteristics between regular ED users and FUs using a traditional statistical model. This study aims to identify patient clusters among FUs by their ED visit patterns over time using deep learning models.

2 - Flexible Designs for Off-placing Patients in Inpatient Wards

Vahid Sarhangian, University of Toronto, Toronto, ON, Canada, sarhangian@mie.utoronto.ca, Carri Chan, Yuan Zhong

A common practice in hospitals is the off-placement of admitted emergency department (ED) patients to a non-primary inpatient ward (IW) when the primary ward is at full capacity. It has been however empirically shown that this leads to an increased length of stay for the off-placed patients. We use a queueing model to study the value of off-placement and provide guidelines for design of practical flexible designs in the presence of the slow-down effect.

3 - Impact of Split-flow Models in Emergency Departments on Patient Outcomes

Juan David Gomez, University of Wisconsin-Madison, Madison, WI, United States, davidgomez@wisc.edu, Brian Patterson, Gabriel Zayas-Caban

Many interventions have been proposed to alleviate crowding in Emergency Departments (EDs). One group of interventions that has gained popularity is the creation of "split flow" models, in which a provider is stationed at patient intake and briefly sees all walk-in patients. In this project, we use observational data from a tertiary teaching hospital to evaluate the impact of the split-flow model on length of stay and other patient outcomes (e.g., ED revisits, readmissions).

4 - Should Everybody be Screen for Diabetes in the Emergency Department?

M Gabriela Sava, Assistant Professor, Clemson University, Clemson, SC, United States, msava@clemson.edu, Ronald G. Pirrallo, Jerrold H. May, Jingyuan Tian

Diabetic screening of ED patients can proactively improve health outcomes, but it is uneconomic to screen all such patients. We present a modeling approach for identifying patients who have a negligible risk of diabetes, so that available resources can be used to screen those with a non-negligible risk.

■ TC63

CC- Tahoma 2

Joint Sessions HAS/MIF: Appointment Scheduling for Outpatient Care

Sponsored: Health Applications

Sponsored Session

Chair: Aleida Braaksma, University of Twente, Enschede, 7500 AE, Netherlands

Co-Chair: Miao Bai, Mayo Clinic, Rochester, MN, 55904, United States

1 - Identifying and Prioritizing Elderly People More in Need of Preventive and Patient-centered Primary Care

Jennifer Mendoza-Alonzo, University of South Florida, Tampa, FL, United States, jennifermend@mail.usf.edu, Jose L. Zayas-Castro

Primary care has a central role in the United States healthcare system given the rise in chronically ill patients. Yet the increase of elderly people and shortage of primary care physicians difficult the timely delivery of primary care. The objective of this work is to develop a decision-making model to prioritize the preferred older adults in receiving preventive and patient-centered primary care. We formulated a multi-objective optimization model and a methodology to identify the older adults that are at the highest risk of worsening their existing conditions. This will reduce the morbidity and mortality, the emergency department visits, the hospitalizations, and thus, the healthcare costs.

2 - Priority Based Templating for Outpatient Specialty Practices

Miao Bai, University of Connecticut, Storrs, CT, 55904, United States, miao.bai@uconn.edu, Bjorn Berg, Esra Sisikoglu Sir, Mustafa Y. Sir

Patient scheduling within outpatient specialties presents unique challenges. Capacity allocation policies are often multi-dimensional in their need to balance competing criteria including clinical urgency, alignment with provider expertise and case mix targets. Further, the need to schedule patients within a pre-determined time frame (timely access) provides motivation for priority-based scheduling templates. We propose a priority-based scheduling approach motivated by specialty appointment data from a large academic medical center. Formulated as a two-stage stochastic program, the problem's structure is used to guide allocating patient groups into a tiered priority scheme.

3 - Overbooked and Overlooked: Machine Learning and Racial Bias in Medical Appointment Scheduling

Shannon Harris, Virginia Commonwealth University, Richmond, VA, 43203, United States, harriss10@vcu.edu, Michele Samorani, Linda Goler Blount, Haibing Lu, Michael Santoro

Machine learning (ML) is often used in scheduling to identify patients with a high no-show risk, and to overbook them in an effort to maximize clinic performance. If those patients are in the same demographic group, they may be overbooked disproportionately more than other patients; a tactic that may result in them incurring a greater expected waiting time. Motivated by a real-world large specialty clinic, we demonstrate that combining ML with optimization causes racial disparity in terms of patient waiting time. We provide a solution to eliminate this disparity, and find that our method can reduce racial disparity by up to 87.5% at a moderate increase in cost when compared to traditional overbooking.

4 - Dynamic Advance Patient Scheduling with Short-Term Follow-Ups

Antoine Sauré, Assistant Professor, University of Ottawa, Ottawa, ON, Canada, Antoine.Saure@telfer.uottawa.ca, Vusal Babashov, Onur Ozturk, Jonathan Patrick

In many healthcare systems, patients require multiple visits to a healthcare provider. In general, the first visit is known as the consult visit and all the subsequent visits are known as the follow-up visits. The latter typically occur according to predefined booking guidelines. We develop an MDP model to efficiently allocate available capacity to consults and follow-up visits in a dynamic fashion. We solve this model using the linear programming approach to Approximate Dynamic Programming and discuss the characteristics of the approximate optimal booking policy (AOP) for a multi-class patient setting. We compare the performance of the AOP policy to that of a myopic policy through simulation.

5 - A Generic Classification System for Appointment Scheduling Literature

Aleida Braaksma, University of Twente, Faculty of EEMCS - SOR (ZI-4013), Netherlands, a.braaksma@utwente.nl, Jasper Bos, Noelle Maria van de Vrugt, Maarten Otten, Richard J. Boucherie

Scheduling appointments occurs in many application areas, such as healthcare, production, and telecommunications. Hence, the vast body of existing research is fragmented and frequently case-oriented. As such, the field of appointment scheduling is in a similar state as machine scheduling before the introduction of Graham's three-field classification. We propose a generic classification system for appointment scheduling, aiming to instigate cross-fertilization between different application areas and thus promote systematic progress of the field. Using our classification, we review and classify the online appointment scheduling literature.

■ TC64

CC- Tahoma 3

Optimization in Clinical Trial Supply Chains

Sponsored: Health Applications

Sponsored Session

Chair: Nan Kong, Purdue University, Biomedical Engineering, West Lafayette, IN, 47906-2032, United States

1 - Drug Supply Chain Optimization for Adaptive Clinical Trials: A Stochastic Programming Approach

Wei-An Chen, Purdue University, Weldon School of Biomedical Engineering, West Lafayette, IN, 47907-2032, United States, Nan Kong

As adaptive clinical trials receive growing attention, they also present challenges on drug supply chain management. To facilitate drug supply decision making in response to trial adaptations, we developed a two-stage stochastic production-inventory-distribution optimization model for trials that allow size re-estimation, adaptive randomization, and arm/dosage-dropping designs. This problem addresses important trial supply aspects, including trial length, resupply schemes, drug wastage, and costs minimization. Our numerical study shows our model can deliver promising operational responses from the supply chain aspect to the trial design adaptiveness.

2 - Stochastic Modeling and Simulation in Clinical Trials

Anh Ninh, College of William and Mary, Williamsburg, VA, United States, Michael Lefew, Vladimir Anisimov

We propose a new framework for end-to-end supply management for clinical trials. Numerical results are illustrated using analytically-based simulations and show wide opportunities to analyze the impact of different effects (risk level, arms, depots, etc.) that has a great potential for applications to real studies.

3 - Improving Clinical Trial Data Management Using Blockchain Technology

Raja Jayaraman, Khalifa University of Science & Technology, Abu Dhabi, United Arab Emirates, raja.jayaraman@kustar.ac.ae, Ilhaam Aziz Omar, Khaled Salah, Mecit Can Emre Simsekler

Clinical trials (CT) data management faces severe challenges in patient recruitment, persistent monitoring, data analytics and accurate reporting. Blockchain technology guarantees the authenticity of transactions without the interference of a third party. The inherent functions including provenance, transparency, decentralized transaction validation and immutability can enable efficiency of CT. Using blockchain based approach in CTs can improve patient retention, data integrity, patient privacy and ensure the CTs comply with the regulatory policies. In this presentation, we propose a novel blockchain based solution for improved CT data management.

4 - Optimizing the Cost of Clinical Trials in Phase 3: A Two-stage Stochastic Programming Approach

Osman Ozaltin, North Carolina State University, 400 Daniels Hall, Industrial and Systems Engineering, Raleigh, NC, 27605, United States, Abdolhossein Tohidi

Phase 3 costs about 75% of the overall expenditure in a clinical trial. This phase involves strategic decisions such as site selection as well as tactical decisions such as patient recruitment and resource allocation across clinical sites. All of these critical decisions are made under uncertainty regarding the success of the drug and patient arrival. We propose a two-stage stochastic program that minimize the expected cost of running clinical trials for a portfolio of new drugs in phase 3. We present numerical experiments providing policy insights for realistic instances.

■ TC65

CC- Tahoma 4

Modeling Safety, Sufficiency, and Cost in the Blood Supply

Sponsored: Health Applications

Sponsored Session

Chair: Alton Russell

1 - Modelling Rare Blood Inventory in Canada

John Blake, Dalhousie University, Halifax, NS, B3H 4R2, Canada, john.blake@dal.ca

Many countries maintain programs to provide blood for patients with complex serology. An analytic approach used to evaluate how rare a blood type must be before frozen blood is necessary. A simulation model was employed to evaluate the impact of inventory on patient access. Results suggested that insufficient donors had been identified to ensure a stable inventory. Simulation results show that some amount of frozen inventory is necessary for most phenotypes. However, holding more than two units apiece did not improve patient access. We conclude that modest amounts of frozen inventory, combined with increased door screening, provides the greatest chance of maximizing patient access.

2 - Strategic Supply Chain Design for Locating Blood Distribution Centers in Korea

Hoon Jang, Korea University (Sejong Campus), Sejong, Korea, Republic of, hoonjang@korea.ac.kr, Hyun-Jung Kim, Jun-Ho Lee

Considering that supply of blood units is limited, developing an efficient supply chain for the right amount of blood for the right number of recipients within the right time window is a particularly important issue in public health. However, in case of Korea, the overall quality of the blood supply chain currently falls far short of the ideal standard. Motivated by this reality, in this study, we propose a mathematical model which optimally allocates blood distribution centers by simultaneously considering uncertainties both in demand and supply. Experimental results using real data present the effectiveness of our approach, which may be helpful in redesigning blood supply management strategies.

3 - Robust Post-donation Blood Screening under Prevalence Rate Uncertainty

Hadi El-Amine, George Mason University, Fairfax, VA, 22030, United States, helamine@gmu.edu

Blood product safety, in terms of being free of transfusion-transmittable infections, is crucial. Under prevalence rate uncertainty, various objective functions, including minimization of a mean-variance objective and minimization of the maximum regret, were considered in order to determine a “robust” post-donation blood screening strategy that minimizes the risk of releasing an infected unit of blood into the blood supply. Efficient and exact algorithms are provided.

4 - An Interactive Hospital Model to Inform Adoption of Platelets Processed with New Technologies

Laura T. Pizzi, Professor and Director, Rutgers University, Piscataway, NJ, 08854, United States, laura.pizzi@rutgers.edu

Many US blood centers and hospitals now transfuse pathogen-reduced (PR) platelets. We describe an interactive model to enable hospital assessment of the budgetary impact for platelet types, including PR vs. conventional platelets tested with a secondary bacterial test. We incorporate acquisition, testing, wastage, and transfusion costs including adverse events. PR cost offsets are also considered due to elimination of bacterial testing and irradiation, increased shelf-life, and higher outpatient reimbursement. The model exemplifies how operations research is applied to inform hospital decision makers concerned with adoption of new blood technologies.

5 - Optimal Safety Policies for Donated Blood: Defer, Test, or Treat?

W Alton Russell, Stanford University, Stanford, CA, United States, altonr@stanford.edu

The number of interventions for managing risk of transfusion-transmitted infections in donated blood grows annually, and the epidemiological profile of donor populations varies geographically and temporally. This makes deciding which blood safety interventions to implement difficult. I present a framework for determining the optimal portfolio of blood safety measures in a given context. This flexible health-economic framework considers demand for donated blood and enables the comparison of policies that combine interventions across three classes: donor deferral, disease marker testing, and donation treatment, where a pathogen inactivation technology is used to reduce risk.

■ TC66

CC- Tahoma 5

Joint Session QSR/Practice Curated: Deep Learning Applications on Multi-Channel Sensors

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Seoung Bum Kim, PhD, Korea University, Seoul, Korea, Republic of

1 - Explainable Failure Prediction for Multi-channel Sensor Data

Mingu Kwak, Korea University, Seoul, Korea, Republic of, min9kwak@korea.ac.kr, Seoung Bum Kim

Prediction of equipment failures is an important issue in various industries. Also, identifying the causes of the failures can be very helpful in determining how to deal with it. In this study, we propose an attention mechanism-based neural network model that yields high performance to predict the failures with interpretability. The model provides attention distributions of sensor-level and segment-level denoting which sensor and segment contribute to the prediction. We evaluate the performance of the proposed method through the real multi-channel sensor data collected from the vehicle engine.

2 - Predicting A 6-component Load Cell of Vehicle Using Regularized Convolutional Neural Networks

Minjung Lee, Korea University, Seoul, Korea, Republic of, leemj2520@gmail.com, Seoung Bum Kim

As technology advances, numerous sensors are attached to driving vehicles. Among them, the six-component load cell incurs significant costs for installation and measurement of their values. To address this issue, we replace those load cell values with predicting them using regularizing grouped weights convolutional neural networks. This model improves predictive performance by regularizing redundant and noisy sensors of multi-channel signal data. We demonstrate the usefulness and applicability of the proposed method through the actual multi-channel dataset of vehicles.

3 - Root Cause Failure Analysis Based on Convolutional Neural Network and Response Activation Map

Yoon Sang Cho, Korea University, Seoul, Korea, Republic of, yscho187@korea.ac.kr, Seoung Bum Kim

Identification of causes of failures is essential to maintain stable manufacturing processes. In this study, we propose a method to predict quality states and analyze causes of failures based on convolutional neural network-based response activation mapping (CNN-RAM). To demonstrate the effectiveness and applicability of the proposed approach, we conduct experiments through the multichannel sensor data that can explain various process conditions in manufacturing systems. The proposed method can successfully detect the causal processes and distinct patterns for each quality state.

4 - Online Learning in Equipment Failure Prediction for Nonstationary Multi-channel Sensor Data

Ji Yoon Lee, Korea University, Seoul, Korea, Republic of, jiyoon.lee52@gmail.com, Seoung Bum Kim

Equipment failure prediction is essential in the construction industry because the failure of vehicles directly leads to a significant loss of productivity. In general, sensors are attached to vehicles to monitor their condition. However, it is challenging to predict failures based on signals collected from sensors because they are nonstationary. To overcome this limitation, we propose an online learning framework for adaptive equipment failure prediction. We demonstrate the effectiveness and applicability of our framework through the real multi-channel sensor data collected from actual construction equipment.

5 - A Stochastic Response Control Method for Optimizing Manufacturing Processes

Jihoon Kang, Seoul, Korea, Republic of, Samsung SDS

Data-driven Model Predictive Control (D-MPC) is widely used for improving control systems in a quantitative way. In this research, we introduce a novel control method named Stochastic Response Control (SRC) which performs properly when a target variable has zero-inflated, intermittent, and time-invariant patterns. Proposed method is consist of 2 main ideas which are stochastic transformation of response variable and coefficient adjustment algorithms that can overcome the current limitations in manufacturing fields. Results of industrial case studies demonstrate the efficacy of SRC especially in the manner of robustness and usability of model based control.

■ TC67

S- Virginia

Simulation Solution & Model Selection

Sponsored: Simulation

Sponsored Session

Chair: Linda Pei, Northwestern University, Evanston, IL, 60202, United States

1 - Variational Bayesian Methods for Stochastically Constrained System Design Problems

Prateek Jaiswal, Purdue University, West Lafayette, IN, United States, Harsha Honnappa

We study system design problems stated as parametrized stochastic programs with a constraint set defined using a coherent risk measure. For the problem to be a well-defined convex program, the use of coherent risk measure ensures the convexity of the feasible set, given the underlying constraint function is convex. We adopt a Bayesian approach that requires the computation of a posterior predictive integral which is usually intractable. Consequently, we propose a variational Bayes-based method to approximately compute the posterior predictive integral. We present our analysis using an M/M/c queueing model to choose the optimal number of servers c for a given coherent risk measure.

2 - Efficient Model Selection for Arrival Data

Zeyu Zheng, University of California, Berkeley, Berkeley, CA, 94720, United States, zyzheng@berkeley.edu, Peter W. Glynn

Appropriately modeling and statistically characterizing arrivals are crucial in service, logistics, and transportation systems. In this talk, we will discuss several new tools that we have developed for statistical estimation and selection for arrival models.

3 - A Simulation-based Iterated Local Search for the In-house Logistics Routing Problem

Marcelus Fabri, Universitat Pompeu Fabra, Spain, Helena Ramalhinho

The objective of this work is to optimize the internal logistics processes in the car assembling company SEAT S.A., a Volkswagen subsidiary. We focus on the In-house Logistics Routing Problem (ILRP), an extension of the VRP. In the ILRP the routes are fixed and cannot be modified; the demand is unknown; the fleet is homogeneous; there are time-window and back-orders constraints. To solve the ILRP, we propose an Integer Linear Programming (ILP) model and a Simulation-based Iterated Local Search (SimILS) algorithm. We conducted experiments based on real company's data. Results showed that the SimILS provided the best overall results overcoming both the ILP approach and the current company's solution.

4 - Sequential Risk Set Inference for Simulation Optimization under Input Uncertainty

Eunhye Song, Penn State University, University Park, PA, 16802, United States, eus358@psu.edu

This talk concerns measuring model risk in simulation optimization when the simulation input model is estimated from finite real-world data. We define the -level risk set as a set of solutions that perform better than a nominal solution by a margin greater than ≥0 with probability greater than , where the probability is taken with respect to the posterior distribution of the input model conditional on the data. Our goal is to propose an algorithm that sequentially simulate an input model-solution pair to efficiently and effectively identify the risk set. Taking a Bayesian approach, we propose two sampling criteria to minimize the estimation error of the risk set.

■ TC68

S- University

Sharing Rides, Durable Goods, and Solvers

Emerging Topic: Sharing Economy & Crowdsourcing

Emerging Topic Session

Chair: Gizem Korpeoglu, United Kingdom

1 - Sharing of Durable Goods: Business Models for Heavy Equipment Manufacturers

Philippe Blaettchen, INSEAD, Fontainebleau, France, philippe.blaettchen@insead.edu, Sameer Hasija, Niyazi Taneri

Technological advances enable new business models, replacing or augmenting ownership-based with access-based usage. These models not only influence sales but also impact after-sales services, an important profit driver in the heavy equipment industry. We focus on understanding the performance of different models by considering salient economic and operational factors. Using a game-theoretic approach, we capture trade-offs that arise in conjunction with after-sales services. We show that these services play an important role in shaping a firm's optimal business model choice, a point which has been overlooked in the existing literature and which deserves close attention by decision-makers.

2 - Competition Between Two-sided Platforms under Demand and Supply Congestion Effects

Fernando Bernstein, Duke University, Durham, NC, United States, fernando.bernstein@duke.edu, Gregory A. DeCroix, N. Bora Keskin

We explore the impact of competition between platforms in the sharing economy. Each platform sets a price charged to customers. A portion of that price is paid to the driver. Customers' and drivers' utilities are sensitive to prices and to congestion in the system. We consider two scenarios. One assumes that drivers work through a single platform. In the second scenario, drivers deliver service through both platforms. We study the equilibrium prices and the supply and demand outcomes that arise at equilibrium. We leverage the model to study practical questions in the ride-sharing industry: surge pricing and the increasingly common practice of drivers choosing to operate on multiple platforms.

3 - Award Structure in Collaborative Contests

James Siderius, Massachusetts Institute of Technology, Cambridge, MA, 02134, United States, Mohamed Mostagir

Society poses a research question whose solution becomes increasingly less valuable over time and can only be discovered through costly effort. The solution requires a series of breakthroughs, and the designer may offer award(s) for each breakthrough. Depending on the award structure, agents may hoard results to prevent others from catching up, which can be socially inefficient. On the other hand, if the designer offers copious awards to encourage agents to share progress, he risks investing huge sums into an intractable problem. We set up the designer's problem of optimally choosing the award structure of this collaborative contest and provide a characterization of the solution.

4 - Do Workers and Customers Benefit from Competition Among On-demand Service Platforms?

Shihong Xiao, University of Minnesota, Minneapolis, MN, United States, xiaosh@umn.edu, Xiaotang Yang, Saif Benjaafar

We study two-sided competition between two on-demand service platforms, where duopoly platforms set price and wage rate to compete for both customers and drivers. By comparing monopoly and duopoly equilibria, we investigate how competition impacts wage rate, price, and firms' profits. We find that when the labor pool size is large, the wage rate and the price in the symmetric duopoly equilibrium is lower than those in the monopoly equilibrium; and it can be the reverse when the labor pool size is moderate. However, the platforms' payoffs are always lower under competition.

■ TC69

S- Seneca

Stochastic Processes and Finance

Contributed Session

Chair: Lei Zou, Rensselaer Polytechnic Institute

1 - Edgy Hermite Processes Are Not Hermite Processes

Joshua B. Levy, Senior Adjunct Professor, University of Massachusetts-Lowell, Lowell, MA, United States, joshua_levy@uml.edu

We examine two finite-variance self-similar processes defined for $t \geq 0$. Both are characterized by a positive integer $k \geq 1$ and a k-dependent pair of real numbers, (p,q), that can differ between the processes. Suppose k is fixed. If $p-q=1$ either process is a version of one of the well-known Hermite processes, and hence is self-similar and has stationary increments. If, however, p-q is "slightly different" from 1, then that process may be described as "edgy Hermite." It fails to have stationary increments, and so it cannot be a version of an Hermite process. In fact, this occurs whenever p-q is not 1. Of further interest in this case is how these two non-Hermite processes compare.

2 - A Set-valued Markov Chain Approach to Credit Default

Bin Zou, University of Connecticut, Storrs, CT, United States, bin.zou@uconn.edu, Dianfa Chen, Jun Deng, Jianfen Feng

We propose a novel credit default model that takes into account the impact of macroeconomic information and contagion effect on the defaults of obligors. We use a set-valued Markov chain to model the default process, which includes all defaulted obligors in the group. We obtain analytic characterizations for the default process, and derive pricing formulas in explicit forms for synthetic collateralized debt obligations (CDOs). Furthermore, we use market data to calibrate the model and conduct numerical studies on the tranche spreads of CDOs. We find evidence to support that systematic default risk coupled with default contagion could have the leading component of the total default risk.

3 - A Two-stage Bayesian Network Model for Corporate Bankruptcy Prediction

Jia Zhai, Lecturer in Finance and Economics, University of Salford, Salford, United Kingdom, j.zhai@salford.ac.uk, Yi Cao

We develop a two-stage Bayesian network for predicting firm bankruptcy. We select financial ratios via the Least Absolute Shrinkage and Selection Operator, establish the topology of Bayesian network and obtain coefficients for conditional probabilities. The empirical results based on 32,344 US firms in 1961-2018 show that our model outperforms 5 alternative methods. It provides an interpretation of its internal functionality by describing how conditional default probabilities are obtained from selected variables and allows sensitivity analyses with respect to changes in input variables. It represents a step towards interpretable machine learning model with strong empirical performance.

4 - Identifying Board of Director Network Influence for Firm Characteristics

Lei Zou, Rensselaer Polytechnic Institute, Troy, NY, United States, zoulei325@gmail.com, Aparna Gupta, Abena Owusu

We utilize network analysis to evaluate the relationship between firms' characteristics and board of director networks. In a sample of 20 firms, we cluster the firms by firm-level characteristics, and develop a multiplex network of the firms' board members consisting of two major layers, one for board members' direct connections and another for their indirect connections. 4 sub-layers of each major layer of the multiplex network. We observe that director networks display significant connectivity at all multiplex network layers and firms belonging to the same cluster display similar director network characteristics, specifically enhanced by appropriate weighting of director network layers.

■ TC70

S- Jefferson A

Joint Session Ebuss/Practice Curated: Experimental Research in e-Business

Sponsored: EBusiness

Sponsored Session

Chair: Qianqian Liu, City University of Hong Kong, Kowloon, Hong Kong

1 - Effects of Cooperative and Competitive Gamification on Fitness Mobile App Use: A Field Experiment

Jiang Qiqi, Copenhagen Business School, Copenhagen, Denmark

Despite the rapid growth of the fitness mobile app market, fitness app companies suffer from a significant portion of poorly motivated, inactive users. In practice, gamification, especially story-based gamification, has been widely adopted as an effective approach to improve system use and reduce user churn rate. However, prior findings suggest that gamification can result in both positive and negative behavioral outcomes, and it remains unclear how to craft a gamified fitness app to maximize its effectiveness in promoting engaged use. Moreover, previous studies mainly emphasized on the designs of rewarding mechanics (e.g., points, badges, and leaderboards) and narrative mechanics (e.g. storytelling) but did not comprehensively investigated the role of social interaction mechanisms in the design of gamification. In this study, we focus on the influences of different social interaction mechanisms (competition, cooperation, and coopetition) on users' task engagement and app use. With a self-developed mobile app, Fitness Castle, we conducted a 2*2 longitudinal field experiment and examined the effectiveness of completion and cooperation among users in a gamified fitness app. Results indicate that competitive game mechanics have a significant positive influence on fitness app use. In addition, when gamified system is purely cooperative, users are not better motivated to use the app more extensively; however, when competitive and cooperative mechanisms are jointly provided, the system use significantly increases.

2 - Investigating Dynamics of Crowdfunding Policy

Keehyung Kim, Chinese University of Hong Kong, Shatin, Hong Kong

Crowdfunding platforms lower entry barriers for less-sophisticated investors to participate in an investment market. However, such inexperienced investors often lack the ability and resources to correctly examine the quality of various projects. In most cases, they heavily rely on information provided by the project managers. To alleviate such information asymmetry, crowdfunding platforms have recently started to introduce a policy requiring project managers to disclose any potential risks involved in the project. This study utilizes economics experiments to understand the role of risk disclosure policy and how it may affect the decisions of both project managers and crowd investors.

3 - Social Information Disclosure in C2C E-commerce: A Natural Experiment

Di Zhou, Institute of Economics, Tsinghua University, Beijing, China, zhoudidkc@gmail.com, Ke Rong

This paper aims to explore the influence of social information disclosure on the sales rate in the online C2C trading market, and a mediator effect of privacy and a moderator effect of trading experience are considered. The empirical results show that partial social information disclosure would decrease the sales rate while full social information disclosure would increase the sales rate. The mediator effect of privacy would increase the sales rate, but the impact is relatively small compared to the trust. The moderator effect of trading experience would only enhance the negative influence of partial social information disclosure.

4 - Digital Communication Channel Migration: A Field Experiment

Zherui Yang, PhD Candidate, Erasmus University, Rotterdam, Netherlands, yang@rsm.nl, Aaron Cheng, Ting Li

When targeting customers for digital communication channel migration, age is generally considered as a significant influencing factor. It is widely believed that younger customers are more likely to communicate digitally. By combining a field experiment with empirical testing, the authors demonstrate that age is not always an effective factor and propose two factors to better target customer in the context of digital communication, namely individual digital activeness and information seeking intensity. it is demonstrated that customers with higher individual digital activeness or lower information seeking intensity are more likely to migrate to digital communication channel.

■ TC71

S- Jefferson B

New Frontiers in Behavioral Operations

Sponsored: Behavioral Operations Management

Sponsored Session

Chair: Evgeny Kagan, Ann Arbor, MI, 48103, United States

1 - Consumers' Trust in Social Responsibility Disclosure: The Role of Supply Chain Visibility

Leon Valdes, University of Pittsburgh, Sloan School of Management, Pittsburgh, PA, 02139, United States, lvaldes@katz.pitt.edu, Tim Kraft, Yanchong Zheng

We experimentally investigate the role of supply chain visibility on consumers' trust in a firm's social responsibility (SR) communications. Specifically, we design a three-player game with the roles of Consumer, Seller, and Worker. The Worker's payment is private information, but the Seller observes a signal about this payment. The Seller can invest to improve this signal's quality, which captures the level of supply chain visibility. Finally, the Seller communicates with the Consumer about the observed signal. With this game, we study whether the level of visibility affects the Consumer's trust in the Seller's communication.

2 - Impact of Quality Bias on Platform Performance

Kyungmin (Brad) Lee, Boston University Questrom School of Business, Boston, MA, 22180, United States, kminlee@bu.edu, Nitin R. Joglekar, Marshall Van Alstyne

A two-sided platform like UBER allows only seller whose quality is above a screening threshold to join. In turn, buyers face a trade-off between ensuring high-quality sellers and guaranteeing enough sellers (or lowering wait-time). We first formally characterize the optimal screening threshold and price in equilibria under the rationality assumption. We then show that this optimality is sensitive to buyer bias in perceiving driver quality. Buyer biases are identified and estimated through controlled experiments. The results document the impact of quality control, in the presence of biases, on a platform's profitability. We provide governance implications that induce favorable behaviors.

3 - Modeling Customer Response to Service Quality Variability with Implications for Pricing

Xiaoyang Long, University of Wisconsin-Madison, Wisconsin School of Business, WI, 53706, United States, xiaoyang.long@wisc.edu, Jordan D. Tong, Gregory A. DeCroix

Given the same expected quality, customers tend to demand less when quality is more variable. How should firms price their service in light of this behavior? In a simple setting of repeat service under stationary but variable quality, we show that a simple and behaviorally robust learning-from-experience formulation - even with risk neutrality - can lead to a quality variability penalty. We study the structure of the optimal pricing policy under this relatively understudied mechanism to generate insight into pricing strategy under quality variability.

4 - Centralized or Decentralized Transfer Prices: A Behavioral Approach for Improving Supply Chain Coordination

Elena Katok, University of Texas at Dallas, Jindal School of Management (SM30), Richardson, TX, 75080, United States, ekatok@utdallas.edu, Sebastian Villa

We study transshipment decisions in a channel with one supplier and two retailers under both decentralized and centralized transfer-price settings. Analytically, the optimal transfer price should depend on the critical ratio, but results show that participants almost ignore it. However, we observe a positive relationship between transfer prices and ordering quantities. We next study the centralized transfer-price setting, with exogenous transfer price. We find that using the theoretical price does not help to increase either profits or coordination. However, by setting a behavioral transfer price, subjects place orders that lead to high supply chain profits.

5 - Agile Project Management – Improved Performance Through Scrum Sprints?

Tobias Lieberum, Technical University of Munich, Mÿnchen, Germany, tobias.lieberum@tum.de

Agile Scrum sprints are characterized by timeboxed progression and output goals for every sprint. In a 2x2 experimental design, we show that in the absence of timeboxed progression and phase-specific output goals participants spend too much time on early compared to later project phases. We refer to this effect as Progression Fallacy. Timeboxed progression mitigates this effect, but only little improves the overall exerted effort. Phase-specific output goals without timeboxed progression have an adverse effect, due to an amplification of the Progression Fallacy. Only the combination of timeboxed progression and phase-specific output goals results in an overall performance uplift.

■ TC72

S- Columbia

Crowdfunding and Other Fintech Phenomena

Sponsored: Information Systems

Sponsored Session

Chair: Hongchang Wang, Mableton, GA, 30126, United States

1 - A Structural Analysis of Bitcoin Cash's Emergency Difficulty Adjustment Algorithm

Vipul Aggarwal, University of Washington, Seattle, WA, 98105, United States, aggarv@uw.edu, Yong Tan

We analyze the equilibrium behaviour of cryptocurrency miners in the wake of a major cryptocurrency fork. Miners are responsible for validating transactions and ensuring smooth functioning of the cryptocurrency platform. Specifically, we are interested in their strategic interactions with the incentives provided by the developers of the newly born minority chain to prioritize its transactions over that of the dominant parent currency. We focus our attention on the Bitcoin (BTC) fork of August 2017 that resulted in the birth of Bitcoin Cash (BCH). BCH's developers introduced emergency difficulty adjustment (EDA) algorithm to incentivize miners to process BCH's transactions over that of BTC's.

2 - Sympathy to the Seemingly Needy: Does Social Influence Alleviate Biases in Medical Crowdfunding?

Yun Young Hur, Georgia Institute of Technology, Atlanta, GA, 30312, United States, Fujie Jin, Xitong Li, Yuan Cheng, Jeffrey Hu

In this study, we conduct a large-scale randomized field experiment with a leading medical crowdfunding platform to examine whether leveraging social influence impacts users' willingness to donate and how the impact differs for cases involving male and female patients. Our results show that social influence alleviates gender bias in donations, particularly for cases lacking other strong signals such as involving patients of young age or with cancer-related conditions. On the other hand, presence of other strong case-level signals makes patient gender a redundant signal and therefore, social influence's impact on willingness to donate is likely similar across patient gender in these cases.

3 - The Value of Alternative Data in Credit Risk Prediction: Evidence from a Large Field Experiment

Tian Lu, Carnegie Mellon University, Pittsburgh, PA, United States, tianlu@andrew.cmu.edu, Yingjie Zhang, Beibei Li

This paper conducts a comprehensive evaluation of the value of alternative data on microloan platforms with a large field experiment. Our machine-learning analyses demonstrate that alternative data can significantly improve the prediction accuracy of borrowers' default behavior and increase platform profits. Moreover, we find that our framework helps financial institutions extend service to more lower-income and less-educated loan applicants from less-developed geographical areas. Our study demonstrates the tremendous potential of leveraging alternative data to alleviate such inequality in the financial service markets, while in the meantime achieving higher platform revenues.

4 - Information Asymmetry and Strategic Early Bidding in Peer-to-Peer Lending

Kai Lu, Assistant Professor of Finance, University of Science and Technology of China, International Institute of Finance, School of Management, Hefei, China, kailu666@ustc.edu.cn, Tat Y. Chan, Zaiyan Wei

We study how investors on peer-to-peer lending platforms utilize their information advantage to bid strategically. Better-informed investors face a tradeoff between the probability of successful funding and the expected return when deciding the timing of bidding. Using a unique dataset from Prosper.com, we document the phenomenon of early bidding (or "squatting") behaviors. We show that "good" loans attract more early bids than "bad" loans. Most importantly, "good" loans with a low ex-ante probability of funding success attract more early bids from better-informed investors. Those early bids would benefit not only the borrowers but also uninformed investors.

■ TC73

S- Boren

Edelman Reprise

Sponsored: INFORMS Section on Practice

Sponsored Session

Chair: Pooja Dewan, BNSF Railway, Fort Worth, TX, 76131, United States

1 - Prospective Dynamic Fraud Control for Optimal Profitability in E-commerce

Anand Oka, Microsoft, Redmond, WA, United States, John Beaver, Yung-Wen Liu

Many merchants conduct their businesses through e-commerce. One major challenge in tackling e-commerce fraud results from dynamic fraud patterns, which can degrade the detection power of risk models and can lead to them failing to detect fraud that has emerging unrecognized patterns. The problem is further exacerbated by the conventional decision frameworks that ignore the follow-up decisions made by other associated parties (e.g., payment-instrument issuing banks and manual review agents). Microsoft developed a new fraud management system (FMS) that effectively tackles these two challenges. It keeps features used by the machine learning (ML) risk models up to date by using real-time archiving, dynamic risk tables, and graph theory. The FMS uses customized long-term and short-term sequential ML models to detect both historical and emerging fraud patterns. It also makes rapid real-time optimal decisions using a dynamic programming approach to optimize the long-term profit by taking into account the aforementioned multi-party decisions. After implementing these innovations over a two-year period (2016 to 2018), Microsoft reduced its fraud loss by 0.52%, thus generating $75 million in additional savings, reduced the incorrect fraud rejection rate by 1.38%, and improved its bank authorization rate by 7.7%. The result was many millions of dollars in additional revenue. These innovations simultaneously prevent fraud and increase bank acceptance. In April 2019, Microsoft launched Microsoft Dynamics 365 Fraud Protection, a cloud-based service available for all e-commerce merchants.

2 - Bus Routing Optimization Helps Boston Public Schools Design Better Policies

Arthur J. Delarue, MIT, Cambridge, MA, 02139, United States, Sebastien Martin

Spreading start times allows school districts to reduce transportation costs by reusing buses between schools. However, assigning each school a time involves both estimating the impact on transportation costs and reconciling additional competing objectives. These challenges force many school districts to make myopic decisions, leading to an expensive and inequitable status quo. For instance, most American teenagers start school before 8:00 AM, despite evidence of significant associated health issues. We propose an algorithm to jointly solve the school bus routing and bell time selection problems. Our application in Boston led to $5 million in yearly savings (maintaining service quality despite a 50-bus fleet reduction) and to the unanimous approval of the first school start time reform in 30 years.

3 - Vattenfall Gets Hundreds of Millions in Gains Through the Application of Operations Research for Offshore Wind Farm Design

David Pisinger, Technical University of Denmark and Vattenfall, Lyngby, Denmark, Martina Fischetti, Jesper Runge Kristoffersen, Thomas Hjort, Michele Monaci

Vattenfall Gets Hundreds of Millions in Gains Through the Application of Operations Research for Offshore Wind Farm DesignMartina Fischetti, Jesper Runge Kristoffersen, Thomas Hjort, Michele Monaci, David PisingerWind energy is a fast-evolving field that has attracted a lot of attention and investments over the past decades. The development into a more mature and competitive market makes reduction of costs and maximisation of power production imperative already in the design phase of new wind farms. Vattenfall is one of the largest producers of electricity and heat in Northern Europe, having the ambition to enable a fossil free living within one generation. To reach this goal Vattenfall developed OR methods to identify the optimal location of wind turbines in a given site, and the corresponding routing for offshore electrical cables. In this way Vattenfall is able to maximize the power output and reduce building costs.The tools developed in our project are now fully deployed in the company and used to design all Vattenfall s offshore wind farms. They allowed for savings the order of 150M€for the complete pipeline of sites under construction (so far).

■ TC74

S- Capitol Hill

Tips for Writing Successful CAREER Proposals

Sponsored: Junior Faculty JFIG

Sponsored Session

Chair: He Wang, Georgia Institute of Technology, Atlanta, GA, 30332-0205, United States

Co-Chair: Ehsan Salari, Wichita State University, Wichita, KS, 67260, United States

Moderator

He Wang, Georgia Institute of Technology, H. Milton Stewart School of Industrial & Sys, 755 Ferst Drive, Atlanta, GA, 30332-0205, United States

Recent NSF Career awardees will share their experience submitting their award winning proposals. NSF program directors will discuss the components of a successful CAREER proposal and the merit review process.

Panelists

- Shipra Agrawal, Columbia University, Industrial Engnr and OR, New York, NY, 10027, United States, ashipra@gmail.com
- Susan R. Hunter, Purdue University, School of Industrial Engineering, West Lafayette, IN, 47907-2023, United States, susanhunter@purdue.edu
- Siddhartha Banerjee, Cornell University, Ithaca, NY, 14853, United States, sbanerjee@cornell.edu
- Edwin Romeijn, Georgia Institute of Technology, Atlanta, GA, United States
- Sheldon H. Jacobson, University of Illinois, Dept of Computer Science, Urbana, IL, 61801-2302, United States

■ TC75

S- Metropolitan Ballroom A

Flash Session III

Flash Session

Chair: Raymond Fan, University of Houston, Cypress, TX, 77429, United States

1 - Clustering Algorithms for Scheduled Ride Sharing

Muhammad Naiman Jalil, Lahore University of Management Sciences, Lahore Cantt., Pakistan, muhammad.jalil@lums.edu.pk

We focus on clustering of customer ride requests in scheduled ride sharing setting. A typical practical problem in scheduled ride sharing often involves thousands of pickup and delivery customers that are candidates for pooled rides. Hence, clustering techniques may be utilized to reduce problem size while identifying requests that are preferable candidates for pooled rides. The problem is unique since each customer request involves pickup, delivery and n-intermediate vertices. In this talk, we discuss the suitability of clustering techniques in data mining for this problem.

2 - Crew Recovery for Airline Operations: Case of Transavia

Evrim Ursavas, Associate Professor in Energy and Logistics, University of Groningen, Groningen, Netherlands, e.ursavas@rug.nl, Albert Schrotenboer, Stuart Zhu

Disruption management in airline operations is becoming increasingly important. We study an airline crew recovery problem where a schedule is repaired in a cost-efficient and a flexible way to cope with additional future disruptions. We evaluate the expected shortfall of reserve crew and propose a set-covering formulation which encapsulates flexibility for reserve crew usage. A tailored branch-and-price algorithm is developed where the pricing problems are solved by a pulse algorithm. Experiments at a Dutch carrier show that the approach delivers more stable schedules, which leads to less last-minute crew alterations (and subsequent delays) and cancellations.

3 - Differentiating Interhospital Transfer Types: Varied Impacts and Diverging Destination Choice Strategies

Raymond Fan, University of Houston, Cypress, TX, United States, raymondfan@bauer.uh.edu, Ming Zhao, David Xiaosong Peng

This study first develops a method to empirically separate clinical interhospital transfers (IHTs) from non-clinical IHTs. Next, we evaluate their impacts on care outcomes and find: (1) clinical IHTs are associated with better outcomes than non-clinical IHTs; (2) for non-clinical IHTs, transfers within the same healthcare system are associated with better outcomes than those out of the system, whereas for clinical IHTs, destinations out of the system are better than those in the system. We use Heckman selection model and propensity score matching to address potential sample selection bias. The results provide managerial insights on IHT destination choice strategies.

4 - Digital Transformation in Retail Banking and the Role of Digital Service Development

Ting Cao, York University, Toronto, ON, Canada, tingc0109@gmail.com, Murat Kristal, Larry Menor

We empirically examine the impact of digital transformation on digital service performance in retail banking. A multi-dimensional construct, digital service development, is developed to capture banks' efforts in generating digital service options through the integration of digital technologies into the operational system. A two-stage approach is used for new multi-item scale development. A global based survey "Innovation in Digital Services" is conducted to collect data. The results offer not only "know-what" of digitalization but also the "know-how" of developing digital services by appropriately managing relevant perspectives to achieve higher digital service performance.

5 - Evaluating Demand-driven Material Resource Planning for an Assembly Line Using Discrete-event Simulation

Kentaro Kuwahara, Chuo University, Tokyo, Japan, a15.xdc5@g.chuo-u.ac.jp, Wenhe Yang, Soemon Takakuwa

Nowadays, manufacturers are required to cope with uncertainties due to product-wide customization and demand uncertainty. Demand-driven MRP (DDMRP) is regarded as an effective approach for managing the multi-echelon demand and replenishment planning for enhancing traditional MRP and other management methods. For evaluating DDMRP, in this study, a discrete-event simulation model for an assembly line of bicycles is constructed to compare performance measures with MRP under the several specified scenarios.

6 - Current Challenges in Development of a Survival Analysis Data Mining Study

Hamidreza Ahady Dolatsara, Clark University, Worcester, MA, United States, hamid@auburn.edu, Fadel Mounir Megahed, Chen Ying-Ju Tessa

This study highlights the issues and challenges that are associated with the development of a data mining (DM) study in the transplantation field. The UNOS dataset was investigated for the development of a data mining study to predict survival of patients within one year after heart transplantation surgery. CRISP-DM (CRoss Industry Standard Process for Data Mining) was adopted as the outline of the DM based survival analysis.

7 - Dominant Strategy Implementation Without Quasilinearity

Brian Baisa, Amherst College, Amherst, MA, United States, bbaisa@amherst.edu

I study the problem of a mechanism designer who wants to implement a social choice function. Agents have non-quasilinear preferences and private values. My main result illustrates a duality between non-quasilinear private value mechanism design settings and quasilinear interdependent value mechanism design settings. In particular, a social choice function is dominant strategy implementable in the non-quasilinear setting if and only if it is ex post implementable in a corresponding interdependent value setting. I apply this result to show that it is impossible to implement non-trivial social choice functions in certain private value settings when agents have multi-dimensional types.

8 - Detecting Anomalous Online Reviewers: A Novel Hierarchical Machine Learning Approach

Naveen Kumar, University of Washington, Bothell, Bothell, WA, United States, Deepak Venugopal, Liangfei Qiu, Subodha Kumar

Online reviews and discussions play a significant role in influencing decisions made by users in day-to-day life. However, the presence of reviewers who deliberately post fake or deceptive reviews for financial or other gains negatively impacts both users and businesses. Unfortunately, automatically detecting such reviewers is well known to be a challenging problem, particularly since fake reviews do not seem out-of-context as compared to genuine reviews. In this paper, we propose a novel machine learning approach for this task. Our approach is highly generalizable, allows us to seamlessly combine both univariate and multivariate distributions into a unified anomaly detection system.

■ TC76

S- Metropolitan Ballroom B

Operations Management V

Contributed Session

Chair: Ju Myung (JM) Song, San Jose State University, School of Global Innovation and Leadership, San Jose, CA, 95192-0164, United States

1 - Multi-process Production Scheduling with Onsite Renewable Energy Integration and Demand Response

Jose Luis Ruiz Duarte, University of Arizona, Tucson, AZ, United States, jlruizduarte@email.arizona.edu, Neng Fan

International efforts to reduce greenhouse gases emissions require industrial sector, one of the major energy consumers, to be involved in its solution. Integrating renewable energy sources to power manufacturing operations is one approach to achieve greenhouse gases reduction targets. In this presentation, the development of an mathematical programming model to obtain the optimal production scheduling of a manufacturing facility with onsite energy storage systems and renewable energy sources with uncertain power output and operating under demand-side management policies is shown. A sensitivity analysis is performed under different production scenarios and policies.

2 - Safety Control in the Online Take-out Food Platform

Xinping Wang, Nanjing Agricultural University, Nanjing, China, wangxp@njau.edu.cn, Shengnan Sun, Lindu Zhao

While the online take-out food platform benefits these food stores, it brings more risk to food safety. This paper investigates how the food safety outcome is affected by the government regulations and platform safety policies. We analyze the effectiveness of these regulations and policies and explore their impact on operational decisions of both platform and food stores.

3 - Sharing Economy in the Cloud: Pricing Schemes of the Peer-to-peer Storage Platforms

YoungJae Jang, KAIST, Seoul, Korea, Republic of, jyj0902@kaist.ac.kr, Jaeung Sim, Kun Soo Park, Daegon Cho

Peer-to-peer (P2P) cloud storage platforms, which allow people to share their unused storage resources to others, have emerged as a solution of the unprecedented surge in data storage demands. In this paper, we analyze a P2P storage platform that aims to maximize its consumer surplus and profit simultaneously.

4 - Cooperation and Competition in the Joint Sales Platform

Hakjin Chung, Assistant Professor, Korea Advanced Institute of Science and Technology (KAIST), Seoul, Korea, Republic of, hakjin.chung@kaist.ac.kr

The joint sales platform provides the seller to earn greater exposure of their products and to reach outside of their usual markets at the shared cost of marketing. At the same time, it spurs competition among partners. We consider a seller's problem of determining whether to participate in the joint sales platform and setting the optimal prices. We also compare a number of different platform settings such as pricing by platform, revenue sharing, and negotiation level.

5 - Hunger Game for a Competitive Supply Chain Simulation

Ju Myung (JM) Song, San Jose State University, San Jose, CA, United States, jumyung.song@sjsu.edu

We invented an online game for OM class, called "Hunger game", which group of students will compete with each others under a supply short by playing. We will discuss how it works and the effectiveness of it to understand Newsvendor model, supply shortage, information's role, and a fair sharing's concept.

■ TC77

S- Fremont

Scheduling III

Contributed Session

Chair: Mario Gnägi, University of Bern

1 - Maintenance Scheduling of Fiber-optics Network

Ramesh Bollapragada, San Francisco State University, San Francisco, CA, United States, rameshb@sfsu.edu, Saravanan Kuppusamy, Uday Rao, Sridhar Seshadri

We present a mathematical optimization model for a novel, practically-motivated maintenance scheduling problem that schedules activities on a fiber-optics network. The objective is to minimize the sum of network outage costs and penalties for not scheduling activities. We solve the problem for a host of instances that differ in number of activities, outage duration, planning horizon, precedence relationships between activities and we identify harder instances that take longer to solve. We note that the solution run time is not monotone in the planning horizon; certain precedence relationships we study and longer outage durations make the instances harder.

2 - Intra-project Learning in Resource-constrained Project Scheduling

Jordan Ticktin, California Polytechnic State University, San Luis Obispo, CA, United States, jticktin@calpoly.edu, Alessandro Hill

It's commonly assumed that experience leads to efficiency, yet this is largely unaccounted for in resource-constrained project scheduling. We consider the case that selected activities can be completed within reduced time when scheduled after activities that result in learning of relevant skills. Using constraint programming, we computationally explore this intra-project learning effect on optimal makespan and problem difficulty across hundreds of thousands of scenarios. We evaluate the impact of multiple parameters such as project size, learning frequency, and learning intensity. We compare different model formulations and lower bounding techniques with respect to their efficiencies.

3 - Multi-mode Resource Constrained Project Scheduling for Pharmaceutical R & D

Hua Wang, Carnegie Mellon University, Pittsburgh, PA, United States, huaw@andrew.cmu.edu, Shekhar K. Viswanath, Steve V. Guntz, John Dieringer, Shankarraman Vaidyaraman, Salvador Garcia-Munoz, Chrysanthos E. Gounaris

The R&D management of a major pharmaceutical company constantly faces a complicated activity scheduling and resource allocation problem. We model this setting as a generalized resource constrained project scheduling problem under various business-driven objectives, and we demonstrate its tractability to address portfolio-wide instances, while we deploy a decision support tool for the systematic and largely automated derivation of optimal solutions. By instantiating the tool with different inputs in the context of automated workflows, we can also use our tool to conduct various analyses to assess the system's ability to cope with sudden changes or react to shifting management strategies.

4 - A Variable Neighborhood Search Based Matheuristic for Resource Constrained Project Scheduling Problem with Learning Considerations

Ying Liu, Nanjing Univeristy, Nanjing, China, liuyingsme@smail.nju.edu.cn, Qian Hu

We study the resource constrained project scheduling problem with learning considerations, including autonomous learning (learning by doing) and induced learning (learning by review). In our problem, the real processing time of an activity becomes variable and depends on the sequencing relation between two activities and review times of other activities in a project. We develop a variable neighborhood search based matheuristic, which fully exploits the mathematical solver CPLEX and VNS framework, in which a set of neighborhoods are iteratively searched by CPLEX within a given time limit.

5 - A Novel Continuous-time Mixed-binary Linear Programming Formulation for the Multi-site Resource-constrained Project Scheduling Problem

Mario Gnägi, University of Bern, Bern, Switzerland, mario.gnaegi@pqm.unibe.ch, Norbert Trautmann

In the multi-site resource-constrained project scheduling problem, some precedence-related project activities which require some scare resources for their execution, and the sites at which these activities can be performed, are given. Sought are a start time and a site for each activity such that the project duration is minimized, and all precedence relationships, resource capacities, and transportation times between the sites are respected. We present a novel continuous-time mixed-binary linear programming formulation and report computational results for test instances from the literature.

■ TC78

S- Greenwood

Data Envelopment Analysis I

Contributed Session

Chair: Xu Wang, Waseda University, 3-4-1 Okubo, Shinjuku-ku, Tokyo 169-8555, Jap, Tokyo, Japan

1 - A Data Envelopment Analysis Approach for Ranking Climate Change Adaptation Technologies

Daiki Min, Associate Professor, Ewha Womans University, Seoul, Korea, Republic of, dmin@ewha.ac.kr

This paper is motivated by observations on the problem for ranking climate change adaptation technologies in Korea. To overcome the drawbacks of using conventional multi-criteria decision analysis, this paper formulate the decision process as a DEA-like model. The decision process involves heavy subjective judgements, which results in data uncertainty. We propose a Monte-Carlo simulation based method to provide robust analysis against the data uncertainty. This paper used the proposed method for a case study in which 11 technologies for climate change adaptation are evaluated.

2 - Analysis of the Operational Efficiency of Public Regional Art Centers in Korea

Sung-min Park, Doctor's course, Kyungpook National University, Deagu, Korea, Republic of, Chae-Bogk Kim

Because of the interest on arts and performance frequency of concerts, the supporting budget for public regional art centers in Korea is increasing. Even though the importance of the operational efficiency of public art centers in each region has been emphasized, there are not many researches on the operations of public art centers. The purpose of this paper is to analyze the operational efficiency of public regional art centers through both DEA and AHP techniques based on the survey data provided by government and to propose various recommendations to inefficient regional public art centers.

3 - Time Series Analysis of Community Banks Using a Combination of Slack Based Efficiency Measure and Social Network Model

Yaoyao Wei, Northwestern Polytechnical University, Xi'An, China, weiyaoyao@mail.nwpu.edu.cn, Haibo Wang, Yang Wang

This paper presents the time series analysis on the performance of 1550 community banks in the US from 1993 to 2006. We use the slack-based efficiency measure on the variables provided by FDIC and a social network model to identify the best-practice frontiers in the community bank system. We choose the size of bank and type of business loan for cross-sectional analysis on the efficiency measure. We perform the same analysis procedure on 1260 non-community banks from the same period for comparison.

4 - Data Envelopment Analysis as a Tool for Process Improvement Based on Agents Efficiencies

Ricardo A. Cassel, Universidade Federal do Rio Grande do Sul, Porto Alegre, Brazil, cassel@producao.ufrgs.br, Vinicius E. Simionato, Daniel P. Lacerda

Studies on efficiency and productivity improvements have been getting more and more attention, both in academic and professional publications. Furthermore, process modelling and improvement are fundamental for companies development. Despite the wide bibliography in these two areas, studies are scarce in their intersection. Hence, this study proposes the application of the Data Envelopment Analysis to evaluate the efficiency of the process agents and its impact on the next stages of the process. A theoretical framework was proposed and a case study was conducted in a financial institution.

5 - DEA Based Bankruptcy Assessment Approach

Xu Wang, Waseda University, Tokyo, Japan, xu.wang@aoni.waseda.jp, Takashi Hasuike

In this research, we propose to use Data Envelopment Analysis (DEA) as an easy-and-quick tool for bankruptcy assessment and prediction. An important feature of DEA is that it is a non-parametric approach which measures the weight estimates of a functional form for classifying observations into two groups: efficient and inefficient DMUs. Moreover, the uniqueness of DEA lies in that it can provide ``what to do" information (improvement goals and plans) for those inefficient DMUs (default firms). Thus, using DEA for bankruptcy assessment give an early warning of the firm's financial performance and provide an improvement goal or plan for the default firm.

■ TC79

S- Issaquah A

Disruption Management and Humanitarian Logistics

Contributed Session

Chair: Shubhra Paul, North Carolina A&T State University, Greensboro, NC, 27405, United States

1 - Consumer Side View of Market Disruptions

Hisanaga Amikura, Sophia University, Tokyo, Japan, h-amikur@sophia.ac.jp, Masahiro Ishii

The purpose of this study is to find decisive factors of disruptive innovation. Whereas many studies suggested that a disruptive innovation arises from product di erentiation, not every di erentiated good leads to disruption of a market. Based on the Japanese Digital Still Camera (DSC) market case, the authors discuss why customer changed their evaluation towards novel products. Combining analyses on 1) hedonic pricing analyses of POS records, 2) contents analyses of press release wordings, and 3) correspondence analyses of hardware specifications, we found that Japanese customers highly evaluate certain product attributes in one time, but their concern went to other factors in short period.

2 - A Reinforcement Learning Approach for Measuring Delivery Variability under Disruption in Emergency Routing

Zohreh Raziei, Southern Methodist University, Dallas, TX, United States, zraziei@smu.edu, Eli Olinick, Khaled Abdelghany

We model the distribution of relief supplies after a natural disaster as a vehicle routing problem with infrastructure distribution and demand uncertainty. In the model, routing decisions are made both to meet estimated demand and to obtain information about actual demand and travel conditions on the road network. We propose a machine learning approach with sequential sampling to address the dynamic nature of the problem.

3 - A Stochastic Programming Model for Dynamic Emergency Supply Planning Considering Transportation Network Development and Traffic Congestion

Qingyi Wang, Sichuan University, Chengdu, China, qingyiwang@scu.edu.cn, Xiaofeng Nie

Some emergency supply planning challenges, like dynamic post-disaster environments and traffic congestion, are seldom addressed in the literature. We propose a stochastic programming model, which integrates pre-disaster supplies pre-positioning and transportation network development decisions with post-disaster transportation decisions. We solve the formulated mixed-integer nonconvex nonlinear program with a generalized Benders decomposition algorithm. Moreover, some case study results are presented.

4 - Fleet Sizing Across Different Humanitarian Organizations

Laura Turrini, European Business School, Oestrich Winkel, Germany, laura.turrini@ebs.edu, Nathan Kunz, Maria Besiou, Luk N. Van Wassenhove

We focus on fleet management and empirically estimate what drives the fleet size of multiple humanitarian organizations in different countries. The analyzed elements include organization size, number of target beneficiaries and country vulnerability. We derive additional insights by comparing our results across the case organizations.

■ TC80

S- Issaquah B

Joint Session TIME/Practice Curated: Management of Product, Service and Data Integration

Sponsored: Technology, Innovation Management & Entrepreneurship

Sponsored Session

Chair: Juliana Hsuan, Copenhagen Business School, Frederiksberg, DK-2000, Denmark

1 - On the Evolution of Knowledge in Online Communities

Nitin V. Mayande, Portland State University, Engineering and Technology Management, Portland, OR, 97207, United States, Charles M. Weber

A study of a diverse set of Twitter conversations over a prolonged period of time provides insights into how knowledge evolves in online communities.

2 - From Likes to Liability: Investigating the Dark Side of Social Media for Entrepreneurs

John N. Angelis, Elizabethtown College, Elizabethtown, PA, 17554, United States, Dmitriy Krichevskiy, Joseph Miller

Entrepreneurs benefit from social media in terms of promotion, networking, education, and many other opportunities. However, recent research and scandals have uncovered the dark side of social media, such as bullying, privacy violations, and addiction. We survey 200 entrepreneurs and 200 business personnel to verify if there are significant differences in social media usage. Our focus is on whether entrepreneurs are more likely to have negative experiences on social media, or to report personal misuse of social media.

3 - The Impact of Ontological Semantic Patent Searches on New Product Development

Charles M. Weber, Portland State University, Engineering and Technology Management, Po Box 751, Portland, OR, 97207, United States, Farshad Madani

A patent search method, which is based on ontologies and semantic analysis, identifies pertinent patents for new product development. The approach, which focuses on the body text of patents, is demonstrably superior to the current state of the art.

4 - Pricing Services Using Transaction Data

Eric Bentzen, Copenhagen Business School, Frederiksberg, Denmark, eb.om@cbs.dk, Juliana Hsuan

Many of the attributes with respect to pricing services are implied by economic theory that can be modeled and investigated by using relevant data from a company. In this paper, we investigate effects that a large service provider use in the pricing of services. From a company we have access to customer transaction data. The dataset has been collected during a period of one year. With the use of transaction data, we expand the microeconomic model and decompose the loyalty parameter into single customers and this opens up for several new microeconomic considerations and new challenges.

■ TC81

S- Kirkland

Shale Energy Optimization

Sponsored: Energy, Natural Res & the Environment/Natural Resources Petrochemicals

Sponsored Session

Chair: John Eason, EQT Production Company, Pittsburgh, PA, 15222, United States

1 - Optimal Artificial Lift Infrastructure Plan for Shale Gas Horizontal Wells under Endogenous and Exogenous Uncertainties

Zuo Zeng, Auburn University, Auburn, AL, United States, zzz0057@tigermail.auburn.edu, Selen Cremaschi

Artificial lift methods (ALMs) are used in horizontal shale-gas wells to lift the accumulated fluids in the well and to help sustain well performance. We present a multistage stochastic programming (MSSP) model for artificial lift infrastructure planning (ALIP) of shale gas horizontal wells. The model incorporates both endogenous, ALM-dependent well production, and exogenous, shale gas price, uncertainties. The objective is to maximize the expected net present value. Finally, we apply MSSP model for a horizontal well located in Woodford shale.

2 - Strategic Planning of Reservoir Development through Adaptive Mixed Integer Optimization under Endogenous Uncertainty

Zukui Li, University of Alberta, Chemical and Materials Engr, Edmonton, AB, T6G 1H9, Canada

During the lifecycle of an oilfield project, development is the most critical phase due to intensive investments required for capital and operating costs. Determining whether it is economic to develop an oilfield or not and finding the best schedule for field development are the main concerns in this field of study. This work presents an optimization method for strategic planning of reservoir development under endogenous reservoir uncertainty. Multistage adaptive optimization is applied to solve the problem where the integer decisions are adjustable. The novelty of the work is the combination of lifting based adaptive binary decision rule and the consideration of endogenous uncertainty.

4 - Shale Gas Development Planning under Uncertainty

John Eason, EQT Production Company, Pittsburgh, PA, 15222, United States, Can Li, Markus G. Drouven, Ignacio E. Grossman

In this paper, we study shale gas pad development under natural gas price uncertainty. We optimize the sequence of operations, gas curtailment and storage on a single pad to maximize the net present value (NPV). The optimization problem is formulated as an mixed-integer linear programming (MILP) model, which is similar to the one proposed by Ondeck et al. [1]. We investigate how natural gas price uncertainty affects the operation strategy in the pad development. Both two-stage and multi-stage stochastic programming are used as the mathematical framework to hedge against uncertainty. Our case study shows that there is value of using stochastic programming when the price variance is high. However, when the variance of the price is low, solving the stochastic programming problems does not create additional value compared with solving the deterministic problem.

■ TC82

S- Leschi

Food Waste

Sponsored: Energy, Natural Res & the Environment/Environment & Sustainability

Sponsored Session

Chair: Arzum E. Akkas, Boston University, Cambridge, MA, 02142, United States

1 - Strategies for Reducing Food Waste in Retailing: a Multi-stakeholder Perspective

Christina Holweg, WU Vienna University of Economics and Business, Vienna, Austria, Christina.Holweg@wu.ac.at, Christoph Teller, Herbert Kotzab, gerald Reiner

Food waste has become an increasing issue for retailers in industrialized nations. The research investigates the causes of food waste across product categories and different retail store formats. In a mixed methods approach face-to-face interviews with store managers serve as the key source of information, complemented by expert interviews. Results reveal that the occurrence of food waste is impacted by various stakeholders and factors as e.g., the retail parent organization, employees, consumer’s shopping behavior, or regulatory constraints. We propose measures of prevention and reduction which also illustrate opportunities behind the issue of food waste.

2 - A Predictive-prescriptive Model for Food Allocation

Debjit Roy, Indian Institute of Management Ahmedabad, Ahmedabad, India, debjit@iima.ac.in, Elena Belavina, Nathan Kallus, Karan Girotra

We study the food allocation problem for government-run schools. We first identify the factors that can explain the demand variance among the schools and then develop a predictive-prescriptive model for optimal allocation of food to different schools. Our methods lead to significantly more children being fed with the same resources; our analysis can be generalized to other allocation problems in resource-constrained environments.

3 - Combating Consumer Food Waste

Ekaterina Astashkina, University of Michigan, Ross School of Business, Ann Arbor, MI, United States, astash@umich.edu, Elena Belavina

We build an analytical model to compare the efficacy of different instruments that combat consumer food waste. We compare (i) taxes and subsidies on groceries, food waste & transportation as a part of the comparison within the fiscal instruments group; (ii) the development of an online grocery outlet against increased store density as a part of the comparison of zoning laws, and (iii) distinct consumer education campaigns. We find that the efficacy of these instruments depends on the market type and its characteristics. The numerical calibration of the model with the demographic data reveals that, in realistic settings, certain instruments are always dominated by others.

4 - Impact of Strategic Farmers on Mechanization Investment in Rainfed Agriculture

Ying (Maggie) Zhang, Clemson University, Clemson, SC, United States, Ying6@clemson.edu, Jayashankar M. Swaminathan

In this paper, we study the optimal investment of farming machinery and seeds for a single crop when farmers could be strategic about commodity pricing. In the computational study, utilizing filed weather data and simulated yield data, we explore the impact of strategic and naive pricing decisions on the optimal investment portfolio.

■ TC83

S- Medina

Policy-Enabling Models for the Power Sector II

Sponsored: Energy, Natural Res & the Environment/Electricity

Sponsored Session

Chair: Afzal Siddiqui, University College London, London, WC1E 6BT, United Kingdom

1 - Investment under Uncertainty and Risk in Competitive Electricity Markets

Golbon Zakeri, University of Auckland, Dept. of Eng Science, Auckland, New Zealand, g.zakeri@auckland.ac.nz, Andrew Philpott, Corey Kok

We will discuss an investment model in electricity generation when the generating agents are competitive yet risk averse. We will discover interesting manifestations of the so called ‘theorem of second best’ when agents are risk averse and the market for risk is not complete. We will also present a numerical study comparing effectiveness of various risk trade instruments and the extent to which they complete the risk market.

2 - A Closed-loop Model of Imperfect Competition in Natural Gas Supply Contracts for Electric Power Generation

Francisco David Munoz, Universidad Adolfo Ibáñez, Santiago, Chile, Mauricio Fernández, Rodrigo Moreno

We develop an open-loop equilibrium model to evaluate if generation firms have incentives to contract or import the socially-optimal volumes of natural gas to generate electricity and illustrate an application of our model using a network reduction of the electric power system in Chile. Our results indicate that strategic firms that own a portfolio of different technologies could have incentives to sign natural gas contracts for volumes that are much lower than the socially-optimal ones. This effect is rather sensitive to the price of natural gas. A high price almost eliminates the incentives of generation firms to exercise market power through natural gas contracts.

3 - Analyzing Time Period Aggregation Methods for Power System Investment and Operation Models with Renewables and Storage

Sonja Wogrin, Comillas Pontifical University, C/ Santa Cruz de Marcenado 26, Madrid, 28015, Spain, sonja.wogrin@comillas.edu, Diego Tejada-Arango, Salvador Pineda, Juan Morales

The transition of the power system from its current state to the power system of the future is heavily influenced by the growing penetration of renewables combined with the increasing importance of storage technologies. We present and compare two different time-period aggregation methods (enhanced representative periods; and, chronological time-period clustering) that allow for the adequate representation of both renewables and storage technologies in power system models. And we assess the quality of both aggregation methods in terms of accurately predicting investment and operating decisions.

4 - Power Based Generation Expansion Planning for Flexibility Requirements

Sonja Wogrin, Universidad Pontificia Comillas, IIT, C/ Santa Cruz de Marcenado 26, Madrid, 28015, Spain, sonja.wogrin@gmail.com, Diego A. Tejada-Arango, Efraim Centeno, German Morales-Espana

Flexibility requirements are becoming more relevant in power system planning. In order to consider these requirements GEP models have recently incorporated Unit Commitment (UC) constraints, using traditional energy-based formulations. However, recent studies have shown that energy-based UC formulations overestimate the actual flexibility of the system. Instead, power-based UC models overcome these problems by correctly modeling ramping constraints and operating reserves. This presentation proposes a power-based GEP-UC model that improves the existing models by including real-time flexibility requirements and the flexibility provided by energy storage.

■ TC84

S- Ravenna A

Flow Relaxations for Energy Models

Sponsored: Energy, Natural Res & the Environment/Energy Sponsored Session

Chair: Antonio J. Conejo, The Ohio State University, Columbus, OH, 43210, United States

Co-Chair: Chen Chen, The Ohio State University, Columbus, OH, 43201, United States

1 - Gas-Aware Unit Commitment

Pascal Van Hentenryck, Georgia Institute of Technology, Atlanta, GA, 30332, United States, Geunyeong Byeon

The increase in Gas-Fueled Power Plants (GFPP), have created significant interdependencies between the electrical power and natural gas transmission systems. This may lead to significant economic and reliability risks as revealed by the 2014 polar vortex event. To mitigate these risks, while preserving the current structure of the markets, this presentation explores the idea of introducing gas network awareness into the standard unit commitment model. The approach is validated on a case study that can reproduce the gas and electricity price spikes experienced in 2014. The results demonstrate that gas awareness in unit commitment is instrumental in avoiding the peaks in electricity prices.

2 - Using Coordinate Transformations to Strengthen QC Relaxations of Optimal Power Flow Problems

Daniel K. Molzahn, Assistant Professor, Georgia Institute of Technology, Atlanta, GA, 60605, United States, molzahn@gatech.edu, Mohammad R. Narimani, Mariesa L. Crow

Recent convex relaxation techniques provide new insights regarding the global optimality of optimal power flow (OPF) solutions. The QC relaxation is a promising approach that convexifies nonconvex terms (i.e., trigonometric and product terms) by enclosing them in convex envelopes. The accuracy of the QC relaxation strongly depends on the tightness of these envelopes. We present several improvements which strengthen QC relaxations of OPF problems via coordinate transformations of the power flow equations. These transformations facilitate the development of tighter envelopes for these equations, resulting in higher quality solutions to the QC relaxation.

3 - A Convex Model for Joint Topology Identification and State Estimation of Power Networks

Ramtin Madani, PhD, The University of Texas at Arlington, Arlington, TX, 76019, United States, ramtin.madani@uta.edu, Tuncay Altun, Ali Davoudi

In this talk, we introduce a convex method for joint topology identification and state estimation of power networks based solely on nodal measurements. We show that the binary and continuous variables accounting for the connectivity and the operating condition of any power network can be determined by minimizing a novel nuclear norm-based objective function. The ability of the proposed approach in offering real-time situational awareness is demonstrated through hardware-in-the-loop simulations for both direct-current microgrids and alternating-current transmission networks.

■ TC85

S- Ravenna B

Flexibility Markets in Energy Systems

Sponsored: Energy, Natural Res & the Environment/Energy Sponsored Session

Chair: Asgeir Tomasgard, Norwegian University of Science and Technology, Trondheim, Norway

Co-Chair: Guray Kara, Norwegian University of Science and Technology, Trondheim, Norway

1 - A Linear Programming Approach to Analyze Cost Saving Responses to Capacity Based Grid Tariffs for Energy Flexible Neighborhoods

Stian Backe, PhD Candidate, Norwegian University of Science and Technology, Trondheim, Norway, stian.backe@ntnu.no, Guray Kara, Asgeir Tomasgard

We propose a linear program to analyze operation of flexible electricity assets to minimize costs under a capacity based power grid tariff. We compare two consumers being billed based on individual load vs. their combined load, and investigate the frequency of adjusting the subscribed capacity level (weekly vs. annually). We find that peak load shaving is triggered when the subscribed level is adjusted over the year. Incentives for load reduction during low demand periods lead to a welfare loss by penalizing utilization of idle grid capacity. Depending on where the bottleneck in the grid is located, the price signal should be based on the combined load of several customers rather than individual loads.

2 - Market Design Considerations for Scarcity Pricing: A Stochastic Equilibrium Framework

Anthony Papavasiliou, CORE, UCLouvain, Voie du Roman Pays 34, L1.03.01, Office b.114, Louvain la Neuve, 1348, Belgium, anthony.papavasiliou@uclouvain.be

The implementation of scarcity pricing is underway in a number of US markets, including Texas and PJM, and is also currently under consideration in Belgium. As the mechanism was originally conceived in the context of a US-style two-settlement system, its implementation in a European setting poses a number of interesting market design dilemmas. These market design choices can affect the back-propagation of scarcity prices to forward day-ahead markets for energy and reserve capacity. We propose a modeling framework for analyzing these market design choices based on stochastic equilibrium.

3 - Adaptive Trading in the Continuous Intraday Market

Gilles Bertrand, FNRS/UCLouvain, Belgium, bertrandgi@outlook.com, Anthony Papavasiliou

The continuous intraday electricity market has become increasingly important in recent years in Europe. Trading in this market is challenging due to the multistage nature of the problem, its high uncertainty, and the fact that decisions need to be made rapidly in order to lock in profitable trades. In this work, we model the problem using Markov Decision Processes, and solve it using policy function approximation. We compare our policy against rolling intrinsic, which is a method that is commonly used in industry, in the German continuous intraday market. We demonstrate an increase in profits of 12.1% relative to rolling intrinsic.

4 - Optimal Scheduling and Bidding of Flexibility for a Portfolio of Power System Assets in a Multi-market Setting

Guray Kara, Norwegian University of Science and Technology, Gloshaugen, Trondheim, 7491, Norway, guray.kara@ntnu.no, Asgeir Tomasgard, Hossein Farahmand

Flexibility is an important concept to cope with uncertainty in energy systems. In this paper, we consider the problem of an actor that manages a set of assets that can provide flexibility based services. We present a stochastic programming model for the dynamic scheduling of a portfolio of assess for which energy and flexibility products can be delivered into multiple markets, like day-ahead, intraday, balancing markets, and flexibility markets. Some of these services and products are locations specific, while others can be delivered system-wide or even cross-border. The purpose in the short-term is to remove bottlenecks, inefficiencies, and ensure security of supply at the minimum cost.

■ TC86

S- Ravenna C

Manufacturing for Materials

Emerging Topic: Advanced Manufacturing

Emerging Topic Session

Chair: Asif S. Iquebal, Texas A&M University, College Station, TX, 77843, United States

1 - Online Monitoring, Detection and Mitigation of Defects in a Self-repairing Hybrid Manufacturing System

Marco Grasso, Politecnico di Milano, Milan, Italy, marcoluigi.grasso@polimi.it, Bianca Maria Colosimo

This talk presents the first Laser Powder Bed Fusion (LPBF) system that is able to detect the onset of a defect and remove it during the process, to achieve first-time-right production capability. The main idea consists of combining a multi-sensor in-situ monitoring system, aimed at detecting defect onsets in a robust and automated way, with a novel in-line defect removal system that "deletes" the defective layers by means of a surface grinding operation integrated into the LPBF system.

2 - Materials Characterization with Acoustic Emission Signatures

Xinyu Zhao, Arizona State University, Tempe, AZ, United States, xzhao119@asu.edu, Hao Yan, Asif S. Iquebal

In this paper, we develop a novel approach to discern certain intrinsic properties, especially of nonequilibrium and rarely occurring material phases. More specifically, we build up a hidden markov model to capture the transition among different materials based on the acoustic signals. We test the prediction accuracy in a Ti-6Al4V fabricated using electron-beam melting (EBM) followed by fine-abrasive finishing processes where the acoustic emission signals generated during this process is able to characterize the hidden material properties.

3 - A Machine Learning Approach for Characterizing Material Microstructure and its Impact on Machinability of Natural Fiber Reinforced Plastic Composites

Zimo Wang, Texas A&M University, College Station, TX, United States

Natural Fiber reinforced Plastic (NFRP) composites offer tremendous ecological advantages for sustainable manufacturing because of their degradability and recyclability. However, the heterogeneity of the NFRP leads to variations of material removal mechanisms over time which adversely impacts the surface finish. We present a machine learning approach for characterizations of machining Natural Fiber Reinforced Plastic (NFRP) materials. The presented model allows accurate estimation of the localized fiber packing density (FPD) and resultant surface integrity using extracted features from sensor signals.

4 - Real-Time Control for Large Scale Additive Manufacturing Using Thermal Images

Feifan Wang, Arizona State University, Tempe, AZ, 85281, United States, feifan.wang@asu.edu, Feng Ju, Kyle Rowe, Nils Hofmann

Large scale additive manufacturing has great application potentials in a variety of industries. To guarantee a good product quality, printing process is subject to constraints on print surface temperature. In this study, thin wall test components are printed, and thermal images are used to monitor print surface temperature. A regression model is built to predict surface temperature accurately. Based on the temperature prediction model, a layer time control method is proposed, which reduces the total build time by about 30%.

5 - An Active Learning Approach to Microstructure Prediction

Ashif S. Iquebal, Texas A. & M. University, College Station, TX, 77840, United States, Bhaskar Botcha, David Shoukr, Raymundo Arroyave, Satish Bukkapatnam

Acceleration of materials discovery and design is contingent on designing optimal experimental design that minimizes the cost of experimentation while reducing the prediction uncertainty. In this work, we present an approach to predict the response surface of the microstructure of an additively manufactured stainless steel with minimum experimental cost and uncertainty. We use a measure of prediction deviation as a metric for actively querying the subsequent experimental runs to guarantee a consistent reduction in the model uncertainty. Results show a significant reduction in the uncertainty via the present approach as compared to randomly selecting the sample points in the design space.

■ TC87

S- Madrona

Joint Session I-SIM/TSL: Simulation Optimization and Applications in Maritime Logistics

Sponsored: Simulation

Sponsored Session

Chair: Jie Xu, George Mason University, Fairfax, VA, 22030, United States

1 - Using Simulation-optimization in Dynamic Resilience Estimation for Container Ports

Weiwen Zhou, George Mason University, Fairfax, VA, United States, Elise Miller-Hooks, Chun-Hung Chen, Loo Hay Lee, Haobin Li

We present a simulation-optimization based approach for dynamic resilience estimation in the context of container ports faced with the risk of disruption from multiple sources. The solution methodology makes use of a port digital twin and techniques from stochastic optimization. The methodology is illustrated on an example application.

2 - Rate-optimal Contextual Ranking and Selection

Jianzhong Du, City University of Hong Kong, Kowloon, Hong Kong, jianzhodu2-c@my.cityu.edu.hk, Siyang Gao, Chun-Hung Chen

We consider R&S in the presence of context, where the context corresponds to some input information to the simulation model and can influence the system performance. This is a new and emerging problem in simulation for personalized decision making. The goal is to determine the best allocation of the simulation budget among various contexts and designs so as to efficiently identify the best design for all the contexts that might possibly appear. We call it contextual ranking and selection. We utilize the OCBA approach in R&S, and solve the problem by developing appropriate objective measures, identifying the rate-optimal budget allocation rule and analyzing the convergence of the selection algorithm.

3 - Maritime Industry Digital Twin Utilizing O2Des.net Standard

Haobin Li, National University of Singapore, Singapore, 117576, Singapore, li_haobin@nus.edu.sg, Muhammad Riza Marhaban, Loo Hay Lee, Ek Peng Chew

For a smarter maritime industry, the digital twin shall be developed in all the four dimensions as follows. Firstly, the Connectivity indicates the level of communication with its physical counterpart; then, the Visibility indicates the ease of perception for human beings; in addition, the Granularity that indicates the detail level of the model; and more importantly, the Analyzability that enables a digital twin with the smartness to support decision making. This talk will give an overview of how the O²DES (object-oriented discrete-event simulation) framework built with the latest .NET Standard complies with the development of the smart digital twin on these four dimensions.

4 - Simulation-optimization Approach for Capacity Planning of Battery-powered Automated Guided Vehicle System

Si Zhang, Associate Professor, Shanghai University, Chenhao Zhou, National University of Singapore, Singapore, Si Zhang, Jie Xu, Loo Hay Lee, Ek Peng Chew

With the development of battery and automated guided vehicle (AGV) technology in maritime industry, the deployment of battery-powered AGV (B-AGV) in major container terminals is getting popular. However, designing and optimizing the mage complex system is not easy in manual way, especially for the system which may cost billions of dollar. In order to minimize the setup cost while maintaining high throughput, a simulation-optimization approach is proposed to find the best configuration in terms of the number of charging stations and their locations, the number of AGVs and quay cranes in a given layout.

■ TC88

S- Cedar A

Health Care, Strategy and Policy I

Contributed Session

Chair: Salar Ghamat, Wilfrid Laurier University, Waterloo, ON, N2L 3C5, Canada

1 - Understanding and Modeling Preterm Birth in the U.S. Using Systems Approach

Alireza Ebrahimvandi, Virginia Tech, Blacksburg, VA, United States, alvandi@vt.edu, Niyousha Hosseinichimeh

Preterm birth rate (PBR) stands out as a major public health concern in the U.S. However, effective policies for mitigating the problem is largely unknown. The complexities of the problem raise critical questions: Why is PBR increasing despite the massive investment for reducing it? What policies can decrease it? To address these questions, we develop a causal loop diagram to investigate mechanisms underlying high preterm rate. Then, we build a simulation model, calibrate it, and apply structural tests and check goodness of fit. This study proposes and tests a theory about why increasing expenditure on medical interventions has not improved health outcomes.

2 - Using Panels Design Strategies to Improve Accessing to the Healthcare Services

Hao-Wei Chen, Assistant Professor, University of Toledo, Toledo, OH, United States, haowei.chen@utoledo.edu

The presentation is to provide managerial insights on how to improve the operational efficiency of healthcare systems through better physician capacity allocation strategies. Specifically, we focus on how a clinic should design its physician panels for a pool of heterogeneous patients to determine whether specialization (e.g., one provider has all high-frequent patients, and the other has all low-frequent patients) or equal assignment (e.g., two providers have identical patient composition) is better by formulating the problem as mathematical models and perform stochastic ordering analysis.

3 - Data Driven Incentive-based Reimbursement Programs Design for Reducing Readmission and Healthcare Expenditure Using Game Theory When Patient Care is Co-produced.

Hasan Symum, University of South Florida, Tampa, FL, United States

To reduce healthcare expenditure and preventable readmission rate, many healthcare organizations are fully or partially transitioning from traditional fee for service (FFS) to other reimbursement policies such as Medicare shared savings program (MSSP), bundled payment (BP), and Pay for performances (P4P). This research examines the impact of the four reimbursement policies on cost reduction and readmission rate in health co-produced game model where patient admission and readmission can be both controlled by the efforts exerted by both patient and hospitals. This analysis enables a healthcare organization to compare the equilibrium outcomes associated with the policies.

4 - Home is Where the Heart Is: An Ecological Systems View of Process Outcomes in Heart Disease

Eric Xu, University of Minnesota, Minneapolis, MN, United States, xuxx1064@umn.edu, Kevin Linderman

The Center for Medicaid and Medicare Services has implemented a Hospital Readmissions Reduction Program to streamline processes and ensure quality outcomes. However, this program has varied success in terms of patient outcomes. This study examines the patient context in greater depth to better explain the varied outcomes for patients with heart disease. The analysis uses patient data from the state of New York to understand how built environment contextual variables can impact treatment process outcomes.

5 - Design of Specialist Response Policies in Emergency Departments: A Data-driven Approach

Cheng Zhu, Assistant Professor, Texas State University, San Marcos, TX, United States, cheng.zhu@mail.mcgill.ca, Beste Kucukyazici, Zhankun Sun

We build a queueing model with a non-homogeneous arrival rate to model the time-dependent demand of specialist consultations in Emergency Departments (EDs), and then figure out the best timing for specialists to fulfill the demands with a controlled waiting time for patients and commuting frequency for specialist. We also recommend different timing policies for all sorts of specialists and the strategy to integrate the policies into the ED patient flow management.

6 - Influencing Primary Care Antibiotic Prescription Behavior: Insights from a Game Theory Approach

Salar Ghamat, Assistant Professor, Wilfrid Laurier University, Waterloo, ON, Canada, sghamat@wlu.ca, Lauren Cipriano, Michael Silverman

Unnecessary antibiotics prescription is a major public health concern and despite guidelines, antibiotics continue to be prescribed at high rates for non-bacterial acute upper respiratory infections. We consider a system that consists of a payer, a healthcare provider, and a sequence of patient experiencing symptoms which could be due to either a viral or bacterial infection. We explore the existence and features of payer-provider contracts designed to reduce antibiotic prescriptions for viral infections and maximize social welfare.

■ TC89

S- Cedar B

Robust Methods in Finance

Sponsored: Finance

Sponsored Session

Chair: Stathis Tompaidis

Co-Chair: Daniel Mitchell

1 - Systemic Risk and Central Clearing Counterparty Design

Hamed Amini, Georgia State University, Atlanta, GA, United States, hamini@gsu.edu

We examine the effects on a financial network of multilateral clearing via a central clearing counterparty (CCP) from an ex ante and ex post perspective. The CCP is capitalized with equity and a guarantee fund. We propose a CCP design which improves aggregate surplus, increases the utility of the banks and of the CCP and reduces the expected shortfall losses on the endusers. We determine the CCP's equity and guarantee fund policies as a Nash bargaining solution. A simulation study based on aggregate market data shows that under our proposed design with hybrid guarantees there exists a unique Pareto optimal equity and guarantee fund policy of the CCP, which reduces systemic risk.

2 - Optimal Scenario Generation for Stress Test

Rohit Arora, University of Texas at Austin, Austin, TX, United States, Rui Gao, Stathis Tompaidis

We consider the regulator's problem of assessing the riskiness of financial institutions using a stress testing procedure. To measure risk, the regulator designs plausible but extreme scenarios, and evaluates the riskiness of financial institutions using the profit and loss values corresponding to these scenarios. We appeal to the optimal experimental design to generate scenarios for stress testing, so that the variance of the riskiness estimator (such as conditional value-at-risk) is minimized.

3 - Robust Portfolio Variance Minimization with Bootstrapping and Factor Model

P.A. Nguyen, University of Minnnesota, Minneapolis, MN, United States

We study a robust portfolio variance minimization problem using bootstrapping. In this approach, we bootstrap the training data to obtain various variance estimations of the portfolio returns. We solve for the portfolio weights that minimize the average variance over k worst-case variances, where k is no more than the number of the bootstrapped samples. The robust portfolio variance minimization problem is derived as a knapsack problem and reformulated into a quadratically constrained linear program problem. We then extend the robust problem to a factor model and show that the robust factor model can result in a better optimal solution than the robust non-factor robust model.

■ TC90

S- Redwood A

Logistics I

Contributed Session

Chair: Teun van Gils, UHasselt, Agoralaan Building D, Diepenbeek, 3590, Belgium

1 - Risk Assessment of Dangerous Cargos in Multimodal Transportation Based on Improved WBS-RBS Method

Jingni Guo, Southwest Jiaotong University, Sichuan, China, 947082371@qq.com, He Zhenggang

In order to effectively assess the security risks in multimodal transport networks, a security risk assessment method based on WBS-RBS and Pythagorean Fuzzy Weighted Average (PFWA) operator is proposed. The risk matrix 0-1 assignment of WBS-RBS is replaced by the Pythagorean Fuzzy Number (PFLN) scored by experts. The security risk ranking values of multimodal transport network are calculated from two processes of whole-stage and phased, respectively, and the safety risk assessment results are obtained. Finally, an example of railway-roadway-waterway intermodal transportation process of dangerous phosphoric acid is given to verify the validity of the method.

2 - Nucleolus Based Cost Allocation Methods for Collaborative Truckload Transportation Procurement

Gultekin Kuyzu, MIT-Zaragoza International Logistics Program, Zaragoza, Spain, Nihat Oner

In truckload transportation procurement networks, identifying the minimum cost collaborative solution and sharing the costs in fair manner are two interrelated and critical tasks for the success of such networks. In this paper, we take a cooperative game theory approach and study the resulting constrained lane covering game. We first show the set of conditions which must be satisfied for the game to have a non-empty core. We propose nucleolus based cost allocation methods. We compare our proposed cost allocation models with alternative cost allocation methods and each other using a set of core stability metrics through computational experiments on randomly generated instances from the literature.

3 - Strategic Design of Highly Responsive Urban Distribution Networks

André Snoeck, Massachusetts Institute of Technology, Cambridge, MA, United States, asnoeck@mit.edu, Matthias Winkenbach

To meet the rising customer expectations in e-commerce, companies promise increasingly short lead-times. The additional required responsiveness puts tremendous stress on the last-mile distribution network. The strategic design of such networks is a major driver of the overall distribution efficiency. We propose an efficient simulation-based optimization approach that captures the non-linear and non-convex characteristics of the strategic network design problem. Leveraging this, we provide insights into key drivers of the performance of highly responsive urban distribution networks.

4 - Integrated Student to School Assignment and School Bus Routing Problem

Azadeh Ansari, West Virginia University, Morgantown, WV, United States, aansari@mix.wvu.edu, Leily Farrokhvar, Behrooz Kamali

In this paper, we propose an integrated mathematical model for student to school assignment and school bus routing problems considering special needs students. The model is linearized and validated for small instances. A heuristic solution approach based on capacitated K-means clustering algorithm is developed that is capable of generating high quality solutions within a reasonable amount of time. We implement our proposed methodology on several randomly generated test instances and a real-world data set. The results suggest that our developed heuristic method outperforms previously developed methodologies.

5 - Improving Network Connectivity of Compromised Digital Logistics Network via Online Optimization

Kam-Fung Cheung, The University of Sydney, Sydney, Australia, kf.cheung@sydney.edu.au, Michael Geoffrey Bell, Man-Chung Yue

A high-level adversary can compromise the digital logistics network and launch attacks inside an organization to deteriorate the network connectivity. In contrast, the defender aims to maximize the network connectivity given that the network is under attack. An online optimization model is proposed to model the arms race between the adversary and the defender. The solution to this model is a defense strategy to allocate resources to improve the network connectivity of the compromised network.

6 - Increasing the Practical Applicability of Models Planning Order Picking Operations

Teun van Gils, Postdoctoral Researcher, UHasselt, Hasselt, Belgium, teun.vangils@uhasselt.be, Sarah Vanheusden, Kris Braekers, Katrien Ramaekers, An Caris

Warehouses are challenged with fulfilling the ever increasing customer requirements, differentiating from competitors, and facing the rising costs of resources. Although literature optimizing order picking operations is comprehensive, managers often do not implement findings from academic research and researchers rarely integrate real-life features when developing planning models. These real-life features could comprise workload equity issues and safety regulations with respect to stock-keeping-units. This study deals with the integration of such real-life features in order picking planning models.

■ TC91

S- Redwood B

Incentives in Healthcare

Sponsored: Manufacturing & Service Oper. Mgmt/Healthcare Operations

Sponsored Session

Chair: Sasa Zorc, University of Virginia, Darden School of Business, Charlottesville, VA, 22903, United States

1 - From Gray to Black: Markets for Counterfeit Pharmaceutical Products

Sasa Zorc, Assistant Professor, University of Virginia, Darden School of Business, 100 Darden Blvd, Charlottesville, VA, 22903, United States

We model the supply chain for Malaria medication in developing countries where one of the key challenges are counterfeiters which often hold significant market share (even >50%). Our work aims to provide prescriptive recommendations to humanitarian organizations which are looking to improve access to medication in those markets. We show that retail subsidies - the currently most prolific subsidy scheme - result in counterfeiters (rather than the patients) being the primary beneficiaries. We identify the optimal mechanism for distributing the subsidies, and study how it varies dependent on market characteristics.

2 - Clinical Ambiguity and Conflicts of Interest in Interventional Cardiology Decision-making

Tinglong Dai, Johns Hopkins University, Baltimore, MD, 21202, United States, dai@jhu.edu, Xiaofang Wang, Chao-Wei Wang

Coronary heart disease leads to one out of every six deaths in the United States, more than any other cause of death. However, decision-making in a cardiac catheterization laboratory— an indispensable segment of cardiology patient care—has not been well understood. We develop a novel analytical model to capture both clinical ambiguity and conflicts of interest in interventional cardiology decision-making. Our analysis highlights the central importance of the endogeneity of advanced testing decisions.

3 - Heteroskedasticity and Bias in Hospital Readmissions Reduction Program and Their Implications

Cem Aydin, London Business School, London, United Kingdom, caydin@london.edu, Nicos Savva, Tolga Tezcan

Yardstick competition is used across Medicare's outcome based reimbursement programs to incentivise quality improvement effort in hospitals. We study the Hospital Readmission Reduction Program (HRRP), which penalizes hospitals up to 3% of their total Medicare reimbursement based on a yardstick competition on their risk adjusted readmission rates. We analyze the methodology used in HRRP to risk adjust readmission rates. We examine the implications of heteroskedasticity and bias in measured performance on quality improvement incentives using a model of HRRP's yardstick competition.

4 - Can Big Data Cure Risk Selection in Healthcare Capitation Programs?

Zhaowei She, Georgia Institute of Technology, Atlanta, GA, 30067, United States, zhaowei@gatech.edu, Turgay Ayer, Daniel Montanera

We analyze the risk selection problem in Medicare Advantage (MA), the largest capitation payment program in the U.S. healthcare market. In practice and current literature, the observed risk selection in MA is primarily attributed to data limitations and low explanatory power (e.g. low R^2) of the current risk adjustment design. However, our study shows that MA cannot eliminate risk selection even if its risk adjustment design becomes informationally perfect (e.g. R^2 =1) in the age of big data. To address risk selection in capitation programs, payers should not solely rely on big data and advanced ML algorithms, and and need to consider mechanisms other than pure statistical risk adjustment designs.

■ TC94

S- Grand Ballroom C

Robust Optimization in Healthcare

Sponsored: Manufacturing & Service Oper. Mgmt/Healthcare Operations

Sponsored Session

Chair: Chaithanya Bandi, 1987, Evanston, IL, 60208, United States

1 - Robust Analytics in Radiation Therapy

Omid Nohadani, Northwestern University, Technological Institute M233, Evanston, IL, 60208-3119, United States, nohadani@northwestern.edu, Dimitris Bertsimas

In radiation therapy and many other applications, statistical estimators serve to derive conclusions from data. However, the conclusions are dependent on uncertainties in the data. We use robust optimization principles to provide robust maximum likelihood estimators that are protected against data errors. We provide efficient algorithms to compute the robust estimators. The performance is demonstrated on simulated data and on a large set of clinical radiation therapy data, where robust estimators offer more reliable decisions. This approach is general and applicable to a broad range of problems.

2 - Robust Optimal Recommendations for Risk-aware Customers

Yam Huo Ow, Northwestern university, Evanston, IL, United States

We consider optimal recommendations problem for risk-aware customers with possibly uncertain risk preferences, where an online insurance platform has to offer the best insurance plan that matches the customers' risk preferences. We present a novel approach to model the uncertainty in risk preferences using robust optimization; and discuss tractable approaches for passive estimation and active learning to construct the uncertainty set of risk preferences from historical and interaction data, respectively. Lastly, we examine Linear Programming formulations which allow for tractable optimization with insightful solutions.

3 - Robust Queueing Inference Engine

Alexej Proskynitopoulos, Student, Northwestern University, Evanston, IL, 60208, United States, alexej.proskynitopoulos@kellogg.northwestern.edu, Chaithanya Bandi

We consider the statistical study of partially observed queueing systems arising in application areas such as hospital networks, data centers and cloud computing systems. We propose an analytically tractable framework based on robust optimization for studying such inference problems . We report results from an implementation of our framework at one of the biggest hospitals in India, where we estimate the service times at various locations throughout the hospital using partial patient flow data. Our methodology achieves significant computational tractability and provides accurate approximations for primitives of the service process relative to simulations.

■ TC95

S- Grand Ballroom D

Sustainable Operations

Sponsored: Minority Issues

Sponsored Session

Chair: Mikhail Gordon, University of Pittsburgh, Pittsburgh, PA, 15224, United States

1 - Target Setting and Sharing Rule in Crowdfunding Platforms

Joyaditya Laik, University of Pittsburgh, Katz Business School, University of Pittsburgh, Pittsburgh, PA, 15260, United States, jol76@pitt.edu

Crowdfunding platforms ‘recommend’ campaigns that surpass their Goal within few days after launch. A quickly achieved target earns the campaign a slot in the recommended section and gives greater visibility. This creates perverse incentives for the creator to set targets even below start-up costs that increase their chance of delinquency. We build conditions under which a creator would set a target that is lower than their setup cost. Furthermore, we show that the information rent, extracted by the platform when setup cost is uncertain, increases with uncertainty about the setup cost.

2 - Learning by Doing: Service Firm with Delay Sensitive Customers

Jing Luo, University of Pittsburgh, Roberto Clemente Drive, Pittsburgh, PA, 15260, United States, JIL204@pitt.edu

Smart city is trying to build a more sustainable society. Our project under Pitt Smart Living aims to reduce the waste, imrpove the efficency of local businesses and smooth the traffic. We analyze the forecasting and planning strategy for service firm with the delay sensitive customers before and after traffic congestion.

3 - Political Ideology and the Use of Autonomous Vehicles

Brian Park, Georgia State University, Atlanta, GA, United States, bpark@gsu.edu, Eunhee Sohn, David Dubois, Yusen Xia

Although political ideology has been extensively studied in relation to consumption behavior and operation management, researchers have paid little attention to how it influences the willingness of consumers to adopt or purchase an autonomous vehicle (AV), which has become one of the most popular technologies in the contemporary age. To fill this void, we explored how individual characteristics—particularly the political ideologies to which people subscribe—affect customers’ inclination to adopt and use automated cars. By using two datasets, we show that Democrats are more willing and likely to adopt an autonomous vehicle than are Republicans.

4 - Direct and Indirect Sustainable Investment in a Competitive Environment

Mike Gordon, University of Pittsburgh, Pittsburgh, PA, 15224, United States, m.gordon@pitt.edu

This research focuses on how consumers react to a company introducing a green product and investing in Corporate Social Responsibility (CSR) in a competitive environment. Though these are both positive investments in the eyes of consumers, green product innovation and CSR investment are analyzed as separate investments.

5 - Conventional Crops or Hops? Optimal Crop Planning Policies with Yield Learning and Forward Contract

Heng Chen, University of Nebraska-Lincoln, HLH 511F, Lincoln, NE, 68588, United States, heng@unl.edu, Jennifer Ryan

With soaring demand for craft beer, hops can offer farmers higher profits than conventional crops, but at the cost of increased demand and yield uncertainty. We formulate a dynamic programming model with yield learning to determine the optimal crop allocation and contract allotment level with the objective of maximizing farm income.

■ TC96

S- Willow A

Service Design in Platform Economy

Sponsored: Service Science

Sponsored Session

Chair: Kejia Hu, Vanderbilt University, Nashville, TN, 37215, United States

1 - Promotional Design for Small Businesses: The Operational Value of Online Deals

Simin Li, Kellogg School of Management, Northwestern University, Evanston, IL, 60208, United States, simin.li@kellogg.northwestern.edu, Kejia Hu, Martin Lariviere

We empirically study how service providers use advance sales period (T) and discount of the online deal, tailoring to operating margin and demand fluctuations, to smooth demand swings and reduce capacity costs. Such operational roles of the online deal are carried out via not only the classic lever discount but also the understudied timing of deal launch in service industries. We conduct counterfactual analyses to show that the optimally designed T mitigates the extreme discounts observed in any “instantaneous” price promotions, and moreover achieves an average profit boost of 23.6%. Compared to discount sensitivity, it is more effective to sway customers’ sensitivity to T for further profit boost.

2 - Intertemporal Segmentation via Flexible-Duration Group Buying

Jingchen Liu, Nanjing University, Nanjing, China, liujingchen32@gmail.com, Ming Hu, Xin Zhai

We study a special form of group buying: it succeeds only if the number of sign-ups reaches a preset threshold, with no duration constraint. Customers with heterogeneous valuations arrive sequentially and decide between signing up for the group buying or purchasing a regular product. We study the product line design with the group-buying sign-up behavior of customers characterized by the rational expectations equilibrium. We show that group buying with flexible duration can result in intertemporal customer segmentation, as different segments might be admitted at different times in the dynamic sign-up process, which is a natural discrimination scheme and has non-trivial implications.

3 - Designing Online Platforms for Offline Services

Leon Chu, USC Marshall School of Business, University Park Campus, Bridge Hall 401T, Los Angeles, CA, 90089, United States, leonyzhu@usc.edu, Xun Wu

Online platforms enable service providers to offer customized services that consumers have increasingly desired. Despite its tremendous value-creation potential, offering customized services encourages greater opportunism from the service providers. We propose a novel platform design where, from its inception, the platform deliberately limits the number of service providers below a certain threshold, even if they are homogenous. Without imposing this threshold, the competition among the service providers may lead to a unique equilibrium under which all the service providers shirk. In contrast, by imposing the threshold, the platform may induce a welfare-enhancing equilibrium.

4 - Supplier Selection Criteria in the Online B2B

Kejia Hu, Vanderbilt University, Nashville, TN, 37215, United States, Yixin Iris Wang

We study the supplier selection criteria and importance of 27 attributes that measures suppliers’ performance in price competitiveness, quality of product, service offerings and delivery.

■ TC97

S- Willow B

Supply Chain, Healthcare

Contributed Session

Chair: Yucheng Chen, University of Connecticut, Dept of Operations & Information Management, School of Business, Storrs, CT, 06269, United States

1 - Inventory Management in an Autologous Cell Therapy Production Facility

Junxuan Li, Georgia Institute of Technology, Atlanta, GA, United States, junxuan.li@gatech.edu, Chelsea C. White

Autologous cell therapy (AuCT) is an emerging therapeutic product that has been proved to be effective for a variety of diseases. We discuss the uniquenesses of AuCT production system, e.g. customer-as-a-supplier, patient-related production capacity process and strict regulatory requirements. Reagent inventory management is critical and challenging in such novel systems. We introduce two dynamic inventory control models for the cases where the bioreactor processes are exogenous or endogenous. We conclude the talk with challenges and outlooks in AuCT supply chain design and operations management.

2 - Modeling and Simulation Efforts for the Pharmaceutical Supply Chain

Safwan Altarazi, Associate professor, German Jordanian University, Amman, Jordan, safwan.altarazi@gju.edu.jo

This presentation highlights adopting integer programming, discrete event simulation, and dynamic simulation to model the pharmaceutical supply chain network. Several network scenarios characterized by considering different number/types of echelons, drugs, decision variables, constraints; different logistics activities, and different goals; are presented. The implementation of the proposed models verified their applicability.

3 - Discussion of Inefficiencies of Liver Transplantation Supply Chain: Study Case Brazil

Daniel de Oliveira Mota, University of Sao Paulo, São Paulo, 04026090, Brazil, João Paulo Monteleone

The present study relies on concepts of healthcare logistics investigating the supply chain of Brazilian liver transplantation system. The identification of wastes along the information management provides insights to propose improvements in public policies based on operations research techniques. It was used integer programming in location problems to identify optimal solutions for positioning the Organ Procurement Organizations (OPO), responsible for guaranteeing the feasibility of the initial stages of the transplantation effort. By the application of the proposed algorithm identify a better use of the number of OPO, optimizing hospital resources allocation.

4 - Supply Chain Performance Analysis of Pharmaceutical Industry

Sangdo Choi, Assistant Professor, Christopher Newport University, Newport News, VA, United States, knowhow.schoi@gmail.com, Jeonghoon Choi

This study explores and expands the theoretical foundations of the strategic group concepts through investigations on the relationship between inventory performance including both total inventory and its discrete inventory, and financial performance in pharmaceutical manufacturing companies. We use the so-called DuPont analysis with earns (or profitability) and inventory turns (or operational excellence) to classify the strategic groups in the pharmaceutical industry. We found that most pharmaceutical companies pursue profitability, moving from the low-right to the top-left section in the Earns-Turns matrix.

5 - Economies of Scope in Community Pharmacy Operations Incorporating Medication Therapy Management into Prescription Workflow

Yucheng Chen, University of Connecticut, Storrs, CT, United States, yucheng.chen@business.uconn.edu, Manuel A. Nunez, Stephanie A. Gernant, Charles Upton

Medication Therapy Management (MTM) is a new type of service provided by community pharmacies and aims to optimize drug therapy and improve therapeutic outcomes of medication-controlled conditions in patients through a direct counselling and follow-up from pharmacists. We formulate queuing and simulation models of a pharmacy's workflow to optimize delivery of MTM services. Using our models, we determine when economies of scope are achieved, redesign workflows, and improve capacity management.

Tuesday, 12:30PM - 2:30PM

■ Poster Competition

Exhibit hall

Tuesday Poster Competition

Competition Poster Session

1 - Pre-Planned Tour for Delivery with Stochastic Demands

Fatemeh Navidi, University of Michigan, Ann Arbor, MI, United States, navidi@umich.edu

We consider the a priori traveling repairman problem, which is a stochastic version of the traveling repairman problem (TRP). Given a metric (V,d) and a root r, the TRP involves finding a tour originating from r that minimizes the sum of arrival-times at all vertices. In its a priori version, we are also given independent probabilities of each vertex being active. We want to find a master tour T originating from r and visiting all vertices. The objective is to minimize the expected sum of arrival-times at all active vertices, when T is shortcut over the inactive vertices. We obtain the first constant-factor approximation algorithm for a priori TRP under non-uniform probabilities.

2 - Optimizing the Assignment of Policemen in Ecuador

Fernanda Salazar, Full time Professor, Escuela Politécnica Nacional, QUITO, Ecuador, fernanda.salazar@epn.edu.ec, Sandra Gutiérrez, Diego Recalde, Ramiro Torres, Polo Vaca, Andrés Vinueza, Estéfano Viteri

The Ecuadorian Police must find an assignment of its human resources so that the security needs of the population are covered as efficiently as possible in every basic geographical area. We design an integer programming model that not only considers the offer and demand of police services but also legal and technical constraints as well as the social dynamics of every area. Then, we compute how to distribute police officers all over the country; suggesting, in addition, what activities they must perform accordingly to their particular qualifications.

3 - The Contract Design Problem for the Aggregator in the Electricity Demand Response Market

Daeho Kim, Pohang University of Science and Technology (POSTECH), Pohang, Gyeongbuk, Korea, Republic of, Dong Gu Choi

In a demand response program, an aggregator and customers make an incentive-sharing contract. When they make the contract, customers have two private information like demand response potential and disutility level. We investigate a contract design problem under asymmetric information. In addition, we find the effect of each private information.

4 - Two Stage Stochastic Choice Modeling Approach for Electric Vehicle Charging Station Network Design in Urban Communities

Seyed Sajjad Fazeli, Wayne State University, Detroit, MI, United States, sajjad.fazeli@wayne.edu, Saravanan Venkatachalam, Ratna Babu Chinnam, Alper E. Murat

In this research, we propose a choice modeling approach embedded in a two-stage stochastic programming model to determine the optimal layout and types of EV supply equipment for a community while considering randomness in demand and drivers' behaviors. Some of the key random data parameters are: EV's dwell time at parking station, battery's state of charge, charging price, distance from home, willingness to walk, drivers' arrival patterns. We propose an outer approximation decomposition algorithm and conduct extensive computational experiments to quantify the efficacy of the proposed approach.

5 - Study of Influencing Factors of Trust Formation in B2C E-Commerce

Cong Cao, Tutor, University of Wollongong, Wollongong, Australia, cong.cao@outlook.com, Jun Yan, Mengxiang Li

This study integrates trust in e-commerce with consumers' attitudes, intention and behaviours as well as external structural guarantees and provides a new perspective for research on e-commerce and related issues. And, the trust model presented in this study integrates the main factors that influence trust online synthesised from different perspectives and levels and discusses their interactions comprehensively and systematically. Moreover, the findings of this study indicate that the perceived channels of information on online reviews and the perceived presentation type of Trusted Third Party and their services are independent factors that influence consumers' trust in online shopping.

6 - Modeling the Role of Efficiency for the Equitable and Effective Distribution of Donated Food

Md Hafizul Islam, North Carolina State University, Raleigh, NC, United States, mislam5@ncsu.edu, Julie Simmons Ivy

Food banks operate intending to serve as many of the food insecure people in the United States as possible with the limited supply available to them. This paper presents a mixed-integer programming model to identify the efficient assignment of demand zones (county) to distribution centers (branches) and equitable allocation of donated food to the demand zones. Data from Food Bank of Central and Eastern North Carolina is used to characterize the model parameters and perform numerical studies. Sensitivity analysis between the user-specified maximum inequity cap and effectiveness shows that significant improvement can be achieved in terms of effectiveness with a marginal sacrifice in equity.

7 - Railroad Track Irregularities Position Accuracy Assessments Using Low Cost Sensors

Bhavana Bhardwaj, Graduate Research Assistent, North Dakota State University, Fargo, ND, United States, bhavana.bhardwaj@ndsu.edu

Deviations from the designed track geometry result in poor ride quality and possible derailments. Thus, regular maintenance of the railroad is very important. This research investigates the potential use of low-cost sensors aboard the hi-rail vehicle to monitor automatically and continuously for inertial events caused by irregular track geometry. Due to the GPS receivers position error, this study introduces a signal processing and statistical method to estimate the position of peak inertial events from multiple traversals and validates its accuracy by comparing the estimated positions of detected irregularities with the actual positions of irregularities recorded by railroad inspector.

8 - Modeling and Prediction for IoT Systems: Methodologies and Practical Implications

Bing Zhang, Texas A&M University, College Station, TX, United States, bing.zhang@tamu.edu, Alaa Elwany, Mohammed Shafae, Shubhi Asthana, Aly Megahed

In IoT systems, not all sensor signals can be monitored at high frequencies due to costly monitoring resources. We develop a modeling framework for predicting IoT signals monitored at low frequencies via estimating the correlation of such signals with ones measured at high frequencies. We also show promising numerical results.

9 - Robust Multi-product Newsvendor Model with Substitution under Cardinality-constrained Uncertainty Set

Jie Zhang, Virginia Tech, Blacksburg, VA, United States, jiezhang@vt.edu, Weijun Xie

This paper studies Robust Multi-product Newsvendor Model with Substitution (R-MNMS), where the demand and the substitution rate are stochastic and is subject to cardinality-constrained uncertainty set. We first show that for given order quantities, computing the worst-case total profit in general is NP-hard. we formulate it as a mixed integer linear program with an exponential number of constraints, and develop a branch and cut algorithm to solve it. For large-scale problem instances, we further propose a conservative approximation of R-MNMS and prove that under some certain conditions, this conservative approximation yields an exact optimal solution to R-MNMS.

10 - Optimizing Diabetes Screening Frequency for At-risk Groups

Chou-Chun Wu, University of Southern California, Los Angeles, CA, United States, chouchuw@usc.edu, Sze-chuan Suen

BMI is a key risk factor for type 2 diabetes, but current guidelines do not provide BMI-category-specific screening frequency recommendations by age and prior testing history. We aim to determine the optimal policy with the above factors using a POMDP. We assume the physician has an estimate of the patient's health state (non-diabetic, prediabetic, or diabetic) at each period, and updates his beliefs about the patient's health given progression trends and observed test results. We show that our model has a threshold policy structure and find that the current recommended screening policy is suboptimal. High-risk individuals should be screened earlier and more frequently.

11 - The Waiting Game - How Public and Private Hospitals Should Work Together to Reduce Waiting Lists

Jorge A. Acuña, PhD Student, University of South Florida, Tampa, FL, United States, jorge@mail.usf.edu, Jose L. Zayas-Castro, Felipe A. Feijoo, Sriram Sankaranarayanan, Rodrigo Martinez, Diego A. Martinez

In this talk, we formulate and solve a bi-level game to mimic market dynamics in two-tier health systems with explicit guarantees of access and waiting time. We discuss how better coordination among public hospitals and governing institutions at a local and regional level can reduce waiting times. At the same time, we show through a bi-objective model the potential role that private hospitals can play as a backup system when the public hospitals struggle to meet demand. We conclude with insights as to how public and private hospitals can cooperate to achieve better results than each hospital acting by itself.

12 - Personal Fitness Monitoring App Data to Assess Community Recovery at Scale: Case Study on Post-hurricane Harvey Recovery of Harris County, Texas

Pariyakorn Maneekul, Department of Industrial & Systems Engineering, University of Washington, Seattle, WA, United States, parim@uw.edu, Zhanlin Liu, Scott Miles, Nicole Errett, Youngjun Choe

Near real-time data of the fitness activity level throughout a community can be a valuable source for assessing community recovery and for building capacity for community resilience. This exploratory study used cycling and running activity records from a personal fitness monitoring app as a proxy for community health and wellbeing. This near real-time, large-scale data enabled us to assess the post-Hurricane Harvey recovery of the fitness activity level throughout Harris County, Texas. The data revealed geospatial patterns of fitness activity level recovery, including how long it took for an affected region's fitness activity level to return to the pre-Harvey level.

13 - Preferred Post-acute Provider Network: An Approach to Improve Care Coordination in Healthcare Continuum

Ineen Sultana, PhD Candidate, Graduate Research Assistant, Texas A&M University, College Station, TX, United States, ineensultana@tamu.edu

Post-acute care (PAC) provides treatment for critical patients following hospital discharge to further improve patient outcomes. To ensure availability of PAC, an effective care coordination from acute care facilities (ACF) to PAC facilities is a long due necessity. Building a Preferred Post-Acute Network (PPN), which involves a contract agreement between ACF and PAC, can strengthen this care coordination. The aim of this work is to develop strategic agreement decisions and resource adjustment planning to form a PPN. In this work, a two-stage stochastic mixed integer model is proposed to optimize the decision features of PPN formation considering uncertainty in resources and patient demand.

14 - Risk Averse Parking Space Optimization in the Era of Autonomous Vehicles and Shared Mobility

QING YE, Virginia Tech, Blacksburg, VA, United States, yqing1@vt.edu

In the era of Autonomous Vehicles (AVs), the different deployment forms of automated vehicles, especially the privately-owned AVs (PAVs) and the shared AVs (SAVs), are envisioned to have dramatically different impacts on modern transportation systems, including parking spaces utilization rates, vehicle ownership, and traffic condition, etc. This work provides a deeper understanding of the parking space requirement and traffic conditions in the era of PAVs and SAVs. A mathematical optimization model, which optimizes the parking space requirement given that the parking demand and the percentages of different deployment forms of AVs as well as the conventional vehicles are stochastic, is built.

15 - Optimal and Fair Decision Trees for Non-discriminative Decision-making

sina Aghaei, USC, Los Angeles, CA, United States

Recently, automated data-driven decision-support tools are increasingly being used in socially sensitive settings. Yet, they may result in discriminative decisions in that they may treat individuals from a specific group unfairly, resulting in disparate treatment and/or impact and violating moral or ethical standards. In this paper, we unify unfairness definitions across classification and regression and propose a mixed integer optimization framework for learning optimal and fair decision trees to prevent disparity. We conduct extensive computational studies that show that our framework yields non-discriminative decisions at lower cost to overall accuracy than other approaches.

16 - The Effects of Organizational Miscommunication on Complex System Performance

John Meluso, PhD Candidate, University of Michigan, Ann Arbor, MI, United States, jmeluso@umich.edu

"Communication Problems" frequently cause failures in complex engineered systems. "Miscommunication" occurs when communication results in a "deficiency" or "problem" that hinders parties from fulfilling their individual or collective values. In three studies, this dissertation demonstrates that organizational miscommunication may substantively affect complex engineered system performance. Semi-structured interviews with practitioners revealed miscommunication about what constitutes a parameter "estimate". Agent-based modeling found that organizational miscommunication about estimate definitions may affect system performance with widespread repercussions.

17 - Rapid Detection of Hot-spot by Tensor Decomposition on Space and Circular Time with Application to Weekly Gonorrhea Data

Yujie Zhao, Georgia Institute of Technology, Atlanta, GA, United States, yzhao471@gatech.edu, Hao Yan, Sarah Holte, Yajun Mei

In many bio-surveillance and healthcare applications, data sources are measured from many spatial locations repeatedly over time. In these applications, we are typically interested in detecting hot-spots, which are defined as structured outliers that are sparse over spatial domain but persistent over time. In this paper, we propose a tensor decomposition method to detect and localize the hot-spots, which is efficient from both statistical and computational viewpoint. We represent raw data as a three-dimensional tensor, and then decompose it by tensor product. A combination of LASSO and fused LASSO is used to estimate parameters, and CUSUM procedure is applied to detect and localize hot-spots.

18 - Unsupervised Anomaly Detection Using Graph Regularized Autoencoders

Imtiaz Ahmed, Texas A. & M. University, College Station, TX, United States, imtiazavi@tamu.edu

In this work, we attempt to solve the problem of anomaly detection when high dimensional data lies near low dimensional manifold. Autoencoders enables us to extract the low dimensional features necessary for anomaly detection. However, the possibility of manifold structure and required local distance preservation is not considered. We use minimum spanning tree, a graph algorithm to approximate the intrinsic distance in presence of manifold structure. We incorporate the MST guided local structure inside the Autoencoder framework as a new regularizer. Hence, it maintains the local invariance property and provide better detection capability compared to Euclidean distance based regularizer.

19 - Minimum Cost Set-Cover Blocker Problem

Luca G. Wrabetz, State University of New York-Buffalo, Buffalo, NY, United States, lucawrab@buffalo.edu

Given a set U of n elements and a collection S of m sets whose union equals U, the set-covering problem is to identify the smallest sub-collection of S whose union contains all the elements in U. Given a cost vector c associated with blocking the selection of the subsets in S, we solve the problem of minimizing the cost of blocking some subsets of S so that the size of the optimal set cover in the resulting problem is at least a given value r. We develop a general formulation for this problem and study the convex hull of feasible solutions. We ran computational experiments over instances staged on graphs, and described applications in the context of drone surveillance.

■ Poster Session

Exhibit hall

Tuesday Poster Session

Poster Session

1 - Left Atrium Segmentation Using Gaussian Mixture Models and Network Flow Optimization

Amirhossein Koneshloo, TexasTech University, Lubbock, TX, United States, amir.koneshloo@ttu.edu

Left atrium segmentation from magnetic resonance imaging (MRI) images provides useful information about the 3D atrial structure and can be further utilized in atrial fibrillation (AF) diagnosis and treatment design. Left atrium segmentation is a challenging task due to uncertainties the MRI images. These uncertainties can be caused by patient heterogeneity, low contract ratio between atrial wall and its neighbor region, and small left atrium size in comparison with large image background. This study aims to estimate a shape prior to produce a robust estimation regarding atrial shape variations via Gaussian mixture modeling, and then apply network flow optimization for accurate segmentation.

2 - Image-guided Additive Manufacturing: From In-situ Sensing to Process Control

Farhad Imani, The Pennsylvania State University, State College, PA, United States, fxi1@psu.edu, Hui Yang, Bing Yao, Ruimin Chen

Quality assurance is one of the key obstacles preventing additive manufacturing (AM) from further proliferation in the manufacturing market. Advanced sensing provides an unprecedented opportunity to increase information visibility, cope with the product complexity, and enable on-the-fly quality control in AM. This paper develops a novel optimal control policy for AM parts whose layerwise defect states can be monitored using advanced sensing systems. We take into account the stochastic uncertainty in the variations of layerwise defects and aim at mitigating the defects before they reach the nonrecoverable stage.

3 - Promoting AI Products in Mothers' Online Social Groups: An Emotional Manipulation Approach

Huigang Liang, University of Memphis, Memphis, TN, 28590, United States, huigang.liang@gmail.com, Yajiong Xue, Yanqi He

Artificial Intelligence (AI) products offer benefits in children's intellectual development, yet have potential privacy concerns. This study investigates how to promote AI products to parents. We conducted an experiment with 400 mothers of toddlers. Using social contagion strategies, we created positive and negative environments in two social media groups. We found that the interplay of mothers' emotional characteristics and environments has an important impact on their AI product acceptance.

4 - Cost-effective Construction of Convolutional Neural Network for Wafer Map Pattern Classification

Jaewoong Shim, Seoul National University, Seoul, Korea, Republic of, shimjw@dm.snu.ac.kr, Seokho Kang, Sungzoon Cho

Wafer maps provide important information for detecting root causes of failure in a semiconductor manufacturing process. A convolutional neural network (CNN) has yielded state-of-the-art performance in wafer map pattern classification. But it is costly to annotate a lot of wafer maps manually to construct labeled training data. We propose a cost-effective wafer map pattern classification scheme based on the active learning of a CNN. The proposed scheme consists of uncertainty estimation, query wafer selection, labeling, and model update. With the repetition of these steps, the performance is effectively increased. The proposed scheme was verified with real-world data.

5 - Artificial Intelligence and the Future of Work: Challenges and a Path Forward

Jinsoo Yeo, Emory University, Atlanta, GA, United States, jinsoo.yeo@emory.edu

This study focuses on AI enabled transformation and the future of work, by assessing extant studies and providing unified answer. First, regression with additional attributes from O*NET suggests that AI amenability is multifaceted and narrow focus on specific aspects may have created discrepancy. Second, this study combines predictions from extant studies and trains a black box machine learning model for unified prediction. Third, this study applies Decision Tree model to the overfitted prediction generated from the black box mode for interpretation. Conclusion highlights the multifacetedness and complex nature of AI amenability.

6 - Draw A Deep Pattern – Temporal Convolution Neural Network Based Novelty Detection for Smartphone User Authentication from Drawing Patterns

Junhong Kim, Korea University / DSBA Lab, Seoul, Korea, Republic of, junhongkim@korea.ac.kr, Hyungseok Kim, Pilsung Kang

We propose DRAW-A-DEEP-PATTERN (DDP), which is deep learning based end-to-end smartphone user authentication method based on during the process of drawing a character or freestyle pattern. We involved 40 participants and they drew the pattern after they had recognized shape, direction and the number of strokes of each pattern. Based on real-world situation, proposed Temporal convolution network (TCN) based model produced excellent performance which average of AUROC, FAR and FRR are 0.99, 1.41% and 1.23% respectively. Also, we confirmed that proposed TCN model not only produced excellent performance and computational efficiency, but also could prevent threat scenario than RNN based model.

7 - Data Analytical Models of Human Trafficking and Interactional Illicit Supply Networks

Laura Devine, PhD Student, University at Buffalo, SUNY, Buffalo, NY, United States, Nafisa Mahbub, Jun Zhuang

Successful disruptions of illicit supply networks require an interrelated understanding of organizational strategy, network structure, and the flow of illicit commodities. This study aims to examine the interactional nature of human trafficking and other multiple illicit trade networks such as drug trafficking to advance this understanding. Using publicly available databases we investigate the dynamics of illicit trade networks through spatial and temporal analysis of crime profiles and socio-economic factors in various geographic locations. The data analysis will provide the vulnerability measures in order to outline the interdiction strategies in a more informative and justified way.

8 - To Hide or Show: An Empirical Examination of Identity Disclosures and Contributions in Online Charity-based Crowdfunding

Lei Ye, Peking University, Beijing, China

Providing services both for borrowers and lenders, lending platforms are widely regarded as intermediaries, where information provided either from lenders or borrowers is of great importance. However, lenders may tend to be anonymous due to their concerns, peer pressure, and social norm, etc. We identify the relationships between lenders' anonymous choices and their lending contributions, and also the influence of others' anonymity on the followers' behavior, through the empirical analysis of one of the largest lending platforms worldwide, Kiva. Drawing on theories of social psychology and economics, we also deep explore the influence mechanism and provide practical suggestions.

9 - Improving Logistic Regression on Imbalanced Data by a Novel Penalized Log-likelihood Function

Lili Zhang, Kennesaw State University, Kennesaw, GA, United States, lzhang18@students.kennesaw.edu, Herman Ray

Penalized log-likelihood functions have been used to improve logistic regression on imbalanced data. However, existing solutions determine penalty weights for observation misclassifications based on either hard hyperparameter (i.e. population proportion) estimation or computational expensive kernel. We propose to include penalty weights for observations in the minority class as decision variables in the log-likelihood function and learn them from data along with model coefficients. Our experimental results show that both discrimination ability and computation efficiency of logistic regression models are improved.

10 - A Group Recommendation Approach Using Group Dynamics Theory

Lu Yang, Hefei University of Technology, Hefei, China, luyang0516@gmail.com

The paper proposes a dynamic group recommendation approach, in a way that allows for improving both the predictive performance and recommendation diversity. The approach is based on group dynamics theory, which suggests the people's consumption behavior is influenced by their affiliated groups, and this group influence varies with time. Besides, the people's susceptibility to group influence is different. The authors develop a group recommendation approach by combining the traditional collaborative filtering methods and the attention mechanism of deep learning.

11 - Securing Gates and Sensor Location Problem Challenges in a Protected Area

Mahdi Fathi, Mississippi State University, Starkville, MS, United States, fathi@ise.msstate.edu, Mohammad Marufuzzaman

Please check the mobile app for this abstract.

12 - Sentiment Analysis of HCAHPS Inpatient Surveys Using Text Mining Methodologies

Sahar Khamsehi, PhD Student, SUN Y. Binghamton, Binghamton, NY, United States, skhamse1@binghamton.edu, Mohammad T. Khasawneh, Mohan Lal Tarun

Deriving actionable insights from unstructured patient satisfaction surveys' data through text mining is one of the untapped potentialities in modern health care. In this study, the data is obtained in form of unstructured texts driven from actual HCAHPS, mail, and phone surveys. The framework is developed to apply unsupervised text mining approaches using Sentiment Analysis and Topic Modeling to obtain insights and knowledge to improve the quality of patient care and operations. Early findings indicate significant correlation between the text tone, survey domain, and satisfaction rate.

13 - Health Monitoring and Anomaly Detection of a Power Plant Boiler Using Unsupervised Autoencoder

Seong-joon Kim, Assistant Professor, Chosun University, Gwangju, Korea, Republic of, seongjoon.kim@chosun.ac.kr, HyoJung Kim

In this study, we propose a data-driven health monitoring methodology to detect an abnormal condition of boiler water-steam system in a coal-fired power plant. The abnormal condition is defined as when the valve position of the desuperheater in the final-reheater is 1% or more, which reduces the boiler thermal efficiency. Based on the boiler big data including coal history and sensor data, preprocessing and feature extraction were performed. Several supervised models and a deep-learning-based autoencoder, which is an unsupervised model, are adopted to develop the anomaly detection model. (This research was supported by Korea Electric Power Corporation. Grant number: R18XA06–46)

14 - Scaling Statewide GPS Trajectories to Match Point Detector Data

Seth Miller, PhD Student, University of Utah, Salt Lake City, UT, United States, Yinhu Wang, Zachary Vander Laan, Nikola Markovic

We consider the problem of inferring statewide traffic patterns by scaling GPS trajectory data that capture 2% of the overall traffic in Utah. We apply a least-square model to scale trajectories such that resulting data best fit vehicle counts measured by traffic sensors. To enhance performance of the model, we propose a new map segmentation approach to optimally partition the region of interest. The scaled trajectories are used to compute statewide performance measures that are of interest to Utah Department of Transportation.

15 - Intrusion Detection Based on Sequential Information Preserving Log Embedding Methods and Anomaly Detection Algorithms

Seung Wan Seo, Korea University, Seoul, Korea, Republic of, zach0206@korea.ac.kr, Donghwa Kim, Pilsung Kang

The defense mechanism should have to comprehend unusual phenomenons or behaviors to successfully handles advanced threats. To achieve this, anomaly detection algorithms are capable of reducing efforts of security experts and securing labeled dataset through post-analysis. It is further possible to distinguish abnormal behaviors more precisely by training classification models if sufficient amounts of labeled dataset is obtained through post-analysis of anomaly detection results. In this study, we proposed an end-to-end abnormal behavior detection method based on sequential information preserving log embedding algorithms and machine learning-based anomaly detection algorithms.

16 - Predicting Airline Sales via Online Customer Reviews

Xiahua Wei, University of Washington, Bothell, WA, United States, Aaron Jacobson, Mark Yo, Thuy Phan

This study investigates if online customer reviews can predict the sales of airlines. Analyzing data of nine major U.S. airlines from 2015 to 2018, we find that the number of reviews (volume), rather than the average rating (valence), is important in predicting both airline revenue and the number of passengers.

17 - An Ongoing Cat-and-mouse Game: The Effect of VPN Block on Social Media Usage in China

Xiaoying Tu, Carnegie Mellon University, Pittsburgh, PA, United States, xiaoying@cmu.edu

In January 2017, China started a 14-month "cleanup" operation that bans any unauthorized use of virtual private networks (VPN), a popular tool among Chinese netizens to access censored information and services such as Instagram and Twitter. We are interested in finding out if blocking VPN is an effective way of cutting back access to censored contents online. By analyzing weekly volume trends of posts in China, Hong Kong and Taiwan around the time of VPN block using DID models, we find that Instagram posts in China increased by 25% more than control regions after VPN block, whereas Twitter posts in China remained as before. In neither case, clamping down VPN cut back access to these censored services.

18 - The Impact of Pre-release Online Activities on Digital Album Sales: A Hidden Markov Model Approach

Xiaoying Tu, Carnegie Mellon University, Pittsburgh, PA, United States, xiaoying@cmu.edu

Internet and digitization present both opportunities and challenges for music industry to maintain and grow digital music sales. Artists rely on social media to promote contents. Pre-release piracy leaks are a threat to revenue. We develop a measure of promotional efforts for a new album based on Twitter intensities and use it as an input to explicitly model the consumers' decision process of purchasing digital albums using hidden Markov model. We find that consumers of different albums respond similarly to social media as well as word-of-mouth. We also find that consumers have an average of 32% possibility to listen to pre-release piracy leaks, which can be quite harmful for legal album sales.

19 - Text Analysis on the Stock Market Thorough "Fake" News Generated by GPT-2

Yoshihiro Nishi, Keio University, Yokohama, Japan, nishi_yoshihiro@keio.jp, Aiko Suge, Hiroshi Takahashi

News has great impacts on asset prices in the financial markets. Many attempts have been reported to ascertain how news influences stock prices. However, the limitations in the number and quality of available data sets usually become the hurdle for the model accuracy. In this study, Reuter's news texts are classified based on each return through LSTM models. "Fake" news generated by GPT-2 was used with original news, and the model accuracy was examined. The results showed that "fake" news data are influential over the prediction of stock price fluctuation.

20 - Measuring the Waterway Congestion Using AIS Data: A Case Study of Houston Ship Channel

Sepideh Zohoori, Lamar University, Beaumont, TX, 77396, United States, Masood Jafarikang, Maryam Hamidi

Waterway congestion is a big problem in Marine transportation, causing many issues such as long waiting time, higher transportation cost, safety, and environmental concerns. The first step in waterway congestion management is quantifying the congestion. To do so, some measures need to be extracted and using the existing data and information, they should be quantified. In this paper, we first introduce some important congestion measures including traversal time, average travel speed, traffic flow, traffic density, and then the way to compute them is discussed. Then, we perform the proposed measures for the Houston Ship Channel (HSC) as a case study. Using AIS data, all the measures are computed, and the results are analyzed. The results indicate the congestion points, congestion time, and the reasons which make congestion in HSC. This study can be applied by the managers and decision-makers to make better decisions to come up with the congestion problem in waterways.

21 - Co-creation in Apps World: Technology as an Operant vs. an Operand

Amrita George, Marquette University, Milwaukee, WI, United States

With the high penetration of mobile technologies globally, it is only natural for firms to leverage these technologies for idea generation and innovation whenever and wherever they occur. Firms can now integrate customer feedback into the development or enhancement of their products/services through the co-creation process. Prior research suggests that IT plays the role of an operand (static) and an operant (dynamic) resource during the co-creation process. Our research seeks to identify the stages and activities of co-creation on mobile platforms as well as various actors involved in the process, and how the nature of the relationship between the actors' change based on the role of technology.

22 - Assessing ISA Tree Risk Assessment Approach Using Econometrics Analysis

Elnaz Kabir, University of Michigan, Ann Arbor, MI, United States, ekabir@umich.edu, Seth Guikema

Tree failure could pose many risks to society. Using the evidence from evaluating characteristics of trees and assessing failure risk on 560 trees based on the above-mentioned qualitative approach, we first evaluate the performance of the ISA tree failure risk assessment approach and compare it with statistical models for formulating tree failing probability. Second, we study the associations between tree conditions and its failure risk. We also evaluate the relationship between different tree trimming practices and the risk of tree failure using econometric models.

23 - Privacy Preserving Methods for Sharing Cyber Risk Exposures

Fransisca Susan, Massachusetts Institute of Technology, Cambridge, MA, United States, fsusan@mit.edu, Andrew W. Lo, Leo de Castro, Nicolas Zhang, Vinod Vaikuntanathan, Taylor Reynolds

Worried about the potential loss of business, companies often fail to report cyberattacks or discuss their risk exposure. We develop methods for sharing and aggregating risk exposures that protect the privacy of all parties involved, and without a trusted third party. We use a homomorphic encryption scheme for floating-point arithmetic based on the ring learning with errors problem. Using this efficient protocol, multiple parties can compute joint functions — average, standard deviation, and logistic regression on aggregated data — without revealing their inputs.

24 - Application of Multivariate Analysis in Prediction of Absenteeism at Work

Motahareh Tavakolikashi, Student, Suny at Binghamton, Binghamton, NY, United States, mtavako1@binghamton.edu, Nasim Khan, Yuqiao Cen, Shuxia Susan Lu

In the highly competitive market, the urge to produce more with utilizing less resources, puts lots of pressure on employees and causes absenteeism at work. In this paper, first different feature selection methods are implemented to identify the most important attributes. Then, different of machine learning algorithms (Decision Tree, Naïve Bayes, Logistic Regression and Linear Discriminant Analysis) have been implemented to achieve an accurate predictive model for absenteeism. The performance of these algorithms is evaluated by several metrics including accuracy, sensitivity, specificity, and AUC of the ROC curve. The results show that the DT algorithm outperforms other algorithms.

25 - Employment Analysis Based on Panel Data in the Background of Industry 4.0

Rongyan Zhou, CentraleSupelec, Université Paris-Saclay, Gif-sur-Yvette, France, rongyan.zhou@centralesupelec.fr, Julie Stal-Le Cardinal

Although Industry 4.0 will bring a great of convenience to our lives, the unemployment brought by new technologies is concerned by the public. Whether the new jobs created by the industry 4.0 can make up for the losses caused by technical unemployment; what is the difference in the new job opportunities created by investment of industry 4.0 in different regions is focused in this paper. The panel data is applied in the study, and the study found that the EU faced the most serious unemployment problem brought by the industry 4.0 technologies, followed by NAFTA, then SAARC and East Asia. Furthermore, the study describes the possible reasons of the difference and proposes future research directions.

26 - Meal Specific Consumption Cycles on Choice Behavior: in Case of Japanese Meal

Hiroki Takahashi, The University of Tokyo, Tokyo, Japan, takahashi@css.t.u-tokyo.ac.jp, Nariaki Nishino

This research analyzed meal specific consumption cycles on consumers' selecting behavior in case of Japanese meals. Particularly, it seems that there is a difference between meals, those you periodically choose like once in a week, and those you are into just for a while and you totally do not eat anymore. However, there are not sufficient researches which are considering these characteristics. In our research, we used data of employees selecting meal at a Japanese restaurant franchise company in order to analyze meal specific consumption cycles and show the importance of clarifying these cycles.

27 - A Modified DEA-based Approach for Selecting Preferred Benchmarks in Social Networks

Sheng Ang, University of Science and Technology of China, Hefei, China, shengang@ustc.edu.cn, Rui Zheng, Fangqing Wei, Feng Yang

We propose a combined method of data envelopment analysis and social network analysis to select preferred benchmarks. The proposed method can identify efficient units that obtain little endorsement from inefficient units and inefficient units that could be good benchmarks. Examples are used to illustrate the practicability and superiority of our proposed method.

28 - Evaluation of a Two-year Addiction Recovery Policing Initiative

Veronica M. White, University of Wisconsin-Madison, Madison, WI, United States, vmwhite@wisc.edu, Meghan Meredith, Laura Albert

The Madison Addiction Recovery Initiative (MARI) is a Smart Policing Initiative in Dane County, Wisconsin, that seeks to offer persons stopped for low-level offenses an alternative to criminal charges via medication-assisted and behavioral drug treatment. Using individual-level data, collected over a two-year period, hypothesis testing is used to demonstrate the impact of the program on health and criminal justice outcomes. The analysis sheds light on the impact of the MARI program on police operations and community health. We also present a framework for policy analysis and evaluation for policing programming.

29 - The Hidden Constraints on Career Mobility: How Skills Determine a Worker's Next Move

Morgan R. Frank, Massachusetts Institute of Technology, Cambridge, MA, United States, mrfrank@mit.edu

Instead of abstract low- and high-skill descriptions of labor, specific skill requirements determine a worker's employability and mobility between labor markets. Here, we employ the O*NET skill database to create a job network that encapsulates information about workers' career mobility and spatial mobility between cities. Our unsupervised analysis reveals a new description for US job polarization and enables new investigations into how changing skill demand may contribute.

30 - The Optimal Bidding Strategy of a Virtual Power Plant with Consideration of Uncertainties

Hyungkyu Cheon, Pohang University of Science and Technology (POSTECH), Pohang, Gyeongbuk, Korea, Republic of, hkyucheon@gmail.com, Yedam Lee, Daeho Kim, Dong Gu Choi, Seongbin Im, Ilhan Ham

Recently, the need for a new energy distribution system has emerged due to the development of energy storage system technology and the increase of small distributed resources. Therefore, in this study, we developed an algorithm to determine the optimal bidding considering uncertainty for virtual power plant.In this study, a prediction model was developed based on data from solar power generation and electricity demand of facilities with energy storage system. In addition, uncertainties regarding forecast errors were quantified through scenario generation. Finally, the optimal bidding profile was derived by the stochastic dynamic programming method .

31 - Reliability-Based Spare Parts Provisioning

Alejandro Najera-Acosta, New Mexico State University, Las Cruces, NM, United States, a_najera@nmsu.edu, Delia J. Valles-Rosales

In industrial practice, the availability of production equipment is influenced by the time of its repair. The latter is also influenced by the time needed to obtain a spare component or replacement. Spare parts inventories are established in order to allow rapid replacement of failed parts and ensure continuity of the operations. However, provisioning of spare parts is a significant challenge because these components have characteristics that differentiate them from other products. For the current work, it is proposed a reliability-based approach, to estimate the failure risk of an equipment when it is subjected to its working conditions.

32 - The Decisions on Assembly with 3D Printing and Their Impact on Subassembly Inventory

Jeonghan Ko, Professor, University of Michigan, Ann Arbor, MI, United States, jko@ajou.ac.kr, Ajou University, Suwon, Korea, Republic of, jko@ajou.ac.kr

This research presents decision models on assembly structure with 3D printing thorough multi-stage assembly, and investigates the impact of this hybrid structure on the product variety and the safety inventory of subassemblies. We develops mathematical models to incorporate 3D printing substitution to conventional component assemblies for the products by combinatorial part assemblies. We show how the model can be used to evaluate the total subassembly inventory levels on the condition of little component commonality. In particular, we show that different product structure and 3D printing selection will lead to different levels of subassembly inventory.

33 - Using Control Charts to Monitor Manufacturing Processes

Vahid Azizi, Iowa State University, Ames, IA, United States, Guiping Hu, Cameron MacKenzie

Statistical process control chart (SPC) is a method to monitor, control, and improve a process through statistical analysis. One of the most important SPC tools is the control chart. Common challenges for control chart applications in manufacturing systems are the identification of the best statistical method, the selection of type of control chart, and the identification of special causes when a change is signaled. Another challenge is to determine which data to monitor in a real-time environment especially when data is collected every second. This study aims to design and present control charts to monitor manufacturing processes in a real-time environment for a manufacturing company in Iowa.

34 - Strategic Production and Sourcing Study under Emissions Trading Scheme

Xin Ma, Monash University, Melbourne, Australia, xin.ma@monash.edu

Shareholders have paid attention to the environmental issues in practice, particularly for the manufacturing industry under environmental regulations. A multi-stage game model is proposed to study the impact of emissions trading scheme on the production and sourcing decisions. Sourcing the materials with lower emissions rate is not a strictly dominate strategy for the manufacturer. The manufacturer can gain more profit with a lower production quantity by using the performance-based sourcing contract in the chain-to-chain competition. The analytical outcomes could provide useful guidance for the manufacturing industry practice in sustainable sourcing and production.

35 - A Two-stage Distribution System Model with Committed Home-delivery-time-dependent Demand

Yue Wang, Texas A&M University, College Station, TX, United States, yuewang92@tamu.edu, Joseph Geunes, Xiaofeng Nie

We consider a two-stage distribution system in which the demand level depends on a committed home delivery order fulfillment lead time. The model assumes periodic and uncertain but bounded demand in each period over a finite horizon. Both the maximum and the expected period demand depend on the committed delivery time. The model's objective is to determine the committed delivery time and inventory stock placement decisions that maximize expected system profit. This model serves as a building block for solving large-scale distribution system planning problems with committed delivery times.

36 - Opaque Pricing Strategy in Healthcare Management

Yuqiong Jiang, Tianjin university, Tianjin, China, junejiang@tju.edu.cn, Zhaofang Mao, Xinghao Yan

In reality, the service quality of the doctor at a hospital with a higher ranking is perceived to be higher. Therefore, the patients would have more incentive to visit the doctors at the hospital with a higher ranking. The patients' asymmetric incentives for doctors at different hospitals can result in serious congestion problem. However, the doctors' real service quality may not be that different. So, we propose a mechanism of opaque pricing applied to healthcare which gives patients more incentive to switch. And comparing with the traditional model and opaque mechanism, we can make some suggestions for pricing decision-making of medical services.

37 - Buyer Power Implications in Contract Farming - An Analysis

Sreehari Karnam, Indian Institute of Management, Indore, India, f15sreeharik@iimidr.ac.in, Hasmukh Gajjar, Bhavin J. Shah

Contract farming has been a growing practice in developing countries especially for the export oriented agricultural crop. However, the food processors, by exerting their bower power, are always at advantage and thus gaining more supply chain profits. Hence, in order to extract more profits, farmers, by considering the buyer power aspect, need to see under what conditions the direct contract with the processors is more beneficial and under what conditions a cooperative structure which in turn contracts with the processor is beneficial. A further analysis with a model considering the aspect of buyer power and channel structure gives a mathematical solution for the farmers to increase their profits.

38 - Sensor Driven Spare Part Management Using Adaptive Stochastic Mixed Integer Programming

Jiachen Shi, Georgia Tech, Atlanta, GA, United States, Murat Yildirim, Nagi Gebraeel

Advances in sensor technology and data mining unlocked accurate methods for predicting life distribution of engineering assets. The visibility attained through these predictions are reshaping many large-scale systems. In this study, we propose a unified framework that utilizes equipment condition monitoring data to jointly optimize condition-based maintenance and inventory decisions. We formulate our problem as a stochastic mixed integer program that accounts for the interplay between maintenance, spare parts inventory, and asset reliability. We present extensive computational experiment the demonstrate the benefits of our proposed approach in terms of cost and reliability.

39 - Manufacturers' Assortment Planning and Pricing in a Two-Tier Supply Chain

Juan Xu, University of Illinois Urbana Champaign, Urbana, IL, United States, juanxu2@illinois.edu, Xin Chen, Qiong Wang

We consider assortment competition in a two-tier supply chain with multiple manufacturers and one wholesaler. Manufacturers choose assortments (and wholesale prices) for the wholesaler, and the latter sets market prices. We characterize a manufacturer's assortment (and pricing) response to other manufacturers' decisions, and establish the existence of an equilibrium.

40 - The Empirical Research on the Impact of Venture Capital on the Cross-border M&A Premium of Chinese Listed Firms

Yingzi Xiong, Associated Professor, Xiamen University, Xiamen, China, Panpan Wu

Based on the M&A events of listed companies in China in 2003-2018, this paper explores the impact of venture capital institutions on the cross-border M&A premium. The study found that listed companies with a background in venture capital have a significantly lower cross-border M&A premium. Based on the results of this study, the author believes that the supervisory function and resource advantages of venture capital institutions play a positive role in the M&A activities in the listed companies.

41 - Interaction Strategies Between Public and Private Sectors in Concession Length of Infrastructure Projects

Zhouyang Lyu, Hohai University, Nanjing, China, lzyseu@hhu.edu.cn

This work studies the intention of private sector investment under tenuous rules of law (Incomplete Information) and associated with concession period length. First, a static game model was created to analyze the tactical concession length, indicating 60% of the legal maximum length. Then, to analyze private investment promotion, another model was created to investigate the influences of the investment ratio. Results from the models show: 1) "zero concession" is negated; 2) only under extreme risk the private sector's motivation will be influenced, but with limitation.

42 - Optimal Payment Policies and Resource-Constrained Project Scheduling with Discounted Cash Flows: The Contractor's Perspective

Michael T. Williams, California Polytechnic State University, San Luis Obispo, CA, United States, mwill143@calpoly.edu, Alessandro Hill, Parth Thakker

We consider new variants of the resource-constrained project scheduling problem with discounted cash flows that are relevant from the contractor's perspective. We use constraint programming to optimize models that foresee different payment policies such as pay per milestone, job, and batch, and study the obtained revenue spectrum for PSPlib instances.

43 - Activating underutilized Resource: Experience in Developing Innovation Service Platform Based on S&T Resources for Beijing-Tianjin-Hebei, China

Ning Xiang, Beijing Science and technology information research institute, Beijing, China, xiangning_xn@163.com

Demand-oriented for the collaborative innovation and industrial development, the Innovation Service Platform based on Science and Technology(S&T) Resources for Beijing-Tianjin-Hebei in China integrates information of nine major types of S&T resources and adopts a three-integration mode, i.e. "S&T resource + digital map, internet + S&T service, expertise wisdom + intelligence forecasting" to provide big-data information service and consulting service. Based on Web GIS framework, the platform formulates data standards and constructes a "3+12" cooperation network in the region.

44 - Earned Value Measurement in Project Buffers Management

Pawel Blaszczyk, University of Silesia, Katowice, Poland, pawel.blaszczyk@us.edu.pl, Tomasz Blaszczyk

The aim of this research was the trial of modelling and optimizing the time-cost trade-offs in project planning problem. The base of the problem description contains both safe and reasonable amounts of time and cost estima-tions and the influence factors matrix. We assumed also the pricing opportunity of performance improving. Finally we try to combine that method with Earned Value Analysis (EVA) method - one of the most popular project audit method.

45 - Multiple Objective Optimization of a Small-scale Renewable Energy System

Eduardo Castillo Fatule, University of Texas-El Paso, El Paso, TX, United States, jecastillofatule@miners.utep.edu, Jose F. Espiritu

Energy use and production in the United States has shifted greatly since the industrial revolution. Today, most of the electricity produced is generated through the burning of fossil fuels. This, however, releases massive amounts of carbon dioxide and other gasses into the atmosphere, which results in increased global temperatures as global warming effects worsen. One of our main objectives in this study is to demonstrate the viability of a renewable energy grid as a reliable, sustainable source of energy. Stochastic analysis is used to evaluate the alternatives, and a metaheuristic process will be used for design optimization.

46 - Optimal Consignment Stocking Policy under Uncertainty

Md Shahriar J. Hossain, Northwestern State University, Natchitoches, LA, United States, msjhossain1@gmail.com, Bhaba R. Sarker

Consignment stocking is an effective approach to bring a product next to the door of a consumer. This supply chain system often encounters both demand and lead-time uncertainty, as well as space and shelf life constraints. In this paper, a joint total cost model is developed and solved to determine the optimum order quantity and reorder point for a single-vendor, single-retailer consignment stocking system. The solution procedure varies depending on the distribution of demand and lead time. For uniformly distributed demand and lead time a gradient method is applied with an iterative search procedure. In case of normal distribution, an exhaustive search procedure is followed within certain domains.

47 - D-Optimal Design for Network A/B Testing

Victoria Pokhilko, Virginia Commonwealth University, Henrico, VA, 23294, United States, Qiong Zhang, Lulu Kang, D'Arcy Mays

A/B testing refers to the statistical procedure of conducting an experiment to compare two treatments, A and B, applied to different testing subjects. It is widely used by technology companies such as Facebook, LinkedIn, and Netflix, to compare different algorithms, web-designs, and other online products and services. The subjects participating in these online A/B testing experiments are users who are connected in different scales of social networks. Two connected subjects are similar in terms of their social behaviors, education and financial background, and other demographic aspects. Hence, it is only natural to assume that their reactions to online products and services are related to their network adjacency. In our research, we propose to use the conditional auto-regressive model to present the network structure and include the network effects in the estimation and inference of the treatment effect. A D-optimal design criterion is developed based on the proposed model. Mixed integer programming formulations are developed to obtain the D-optimal designs. The effectiveness of the proposed method is shown through numerical results with synthetic networks and real social networks.

48 - The Lexicographic Winner Determination Problem (WDP) for Real World Combinatorial Auctions

William K. Schwartz, Co-founder, Illinois Institute of Technology, Chicago, IL, United States, wkschwartz@gmail.com, Ingraham and Schwartz Auction Advisers, LLC, Arlington, VA, United States, wkschwartz@gmail.com

WDP asks which combination of indivisible bids for discrete goods maximizes revenue. Textbooks present it as an integer program (IP) constrained by goods' supplies. IP can be cumbersome to use for national radio spectrum auctions, which have tie breaking rules and side constraints, and often require repeated solving of related WDPs. We introduce a more realistic formalism, and a warm-startable dynamic programming algorithm for solving it, generic enough for real auctions and with a simple data interface. A custom radix tree accelerates memoization. Work on fathoming and relaxation is ongoing.

49 - Service Network Design for Regional Multi-modal Rail Transit System

Yihan Wang, Master candidate, Southwest Jiaotong University, Chengdu, China, johnw@my.swjtu.edu.cn, Lan Liu, Weike Lu, Jiannan Mao, Yalong Lao

Focusing on making full use of transport capacities and transfer passengers during the rush hour by allocating the components of the multi-modal rail transit system, this paper formulated the MINLP model which minimized the generalized travel cost of the passenger and considered the multiple services departing interval. Furthermore, a MILP model was reformulated by modifying the nonlinear constraints according to the change of notation. This new model was tested by a numerical example and solved by Cplex solver. The results showed that the reconstruction modal was valid to the real problem and illustrated the superiority in the computation.

50 - Operational Constroperational Constraints for Real-world VRP

Heather Moe, ESRI, Redlands, CA, United States, Yuzhe Yan

Solving a standard VRP to optimality is a difficult challenge. However, the optimal solution is often unrealistic and infeasible in the real world. Additional constraints must be added to the model to make it operationalizable. In this analysis, we examine qualitative constraints such as how best to cluster a solution; balancing workloads but still being reasonably efficient; sequencing orders on a "Neighborhood" basis to facilitate repeat attempts; and prioritizing high revenue orders but visiting nearby lower priority ones. We will look at the multitude of ways these can be defined quantitatively to fit a company's business rules, and the implications of the different interpretations.

51 - Failure Detection for K-out-of-N Systems

Tonguc Unluyurt, Sabanci University, Istanbul, Turkey, tonguc@sabanciuniv.edu

We consider a k -out-of- n system that has just failed. There is an associated cost of testing each component. In addition, we have apriori information regarding the probabilities that a certain set of components is the reason for the failure. The goal is to identify the subset of components that have caused the failure with the minimum expected cost. In this work, we provide exact and approximate policies that detect components' states in a failed k -out-of- n system. We propose two integer programming (IP) formulations, two novel Markov decision process (MDP) based approaches, and two heuristic algorithms.

52 - Routing of Platform Supply Vessels in Offshore Oil and Gas Logistics

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This work introduces a novel feature-rich maritime routing problem, which models cargo transport activities performed by Platform Supply Vessels in offshore oil and gas logistics. We present a mathematical formulation and results inspired by real operator data.

53 - Comparison of Linear and Nonlinear Analysis for Train Routing and Scheduling Problem

Yuan Xu, Lecturer, Rensselaer Polytechnic Institute, Troy, NY, United States

This paper presents a comparison of a novel mixed integer linear program and a traditional nonlinear program on solving a train routing problem combined with a train scheduling problem in a railway network including both single and multi-track sections. The proposed models consider several important elements and issues besides train route selection, such as headway, trip time, side capacity, conflict at common stations, and overtaking between trains. A numerical study is applied to perform the comparison analysis.

54 - Strengthened SOCP Relaxation and Efficient Hybrid Bounds Tightening of ACOPF

Yuanxun Shao, Georgia Institute of Technology, Atlanta, GA, United States, yuanxun@gatech.edu, Dillard Robertson, Joseph Scott

ACOPF problem is fundamentally important for power grid operations at all scales. The key challenge for global methods is that tens of thousands of optimization variables making exhaustive branching procedures impractical. To address these challenges, this talk presents a strengthened SOCP relaxation based on McCormick envelopes, cycle basis relaxations, and reverse cone cuts that are added dynamically. We also first identify a minimal subset of the variables for optimization-based bounds tightening. Next, we utilize simple bound updates based on interval arithmetic. The advantages of our proposed method will be demonstrated through extensive tests on NESTA benchmarks.

55 - Modeling Framework and Decomposition Scheme for On Demand Mobility Services with Ridesharing and Transfer

Sepide Lotfi, Southern Methodist University, Dallas, TX, United States

A modeling framework for the operations of on demand mobility services (ODMS) in urban areas is presented which provides the capabilities to analyze ODMS operations while representing emerging services such as ridesharing and transfer. The problem is formulated as a mixed integer program and an efficient decomposition based methodology is developed for its solution. The results of a set of experiments show that increasing the number of passengers willing to rideshare and/or transfer improves the overall performance of ODMS as it increases number of served passengers and associated profit and reduces the number of used vehicles.

56 - Optimizing Power System Resilience Using Conditional Value-at-Risk Within a Markov Decision Process Framework

Thanh To, Clemson University, Clemson, SC, United States, tto@clemson.edu

We propose a model that incorporates the Conditional Value-at-Risk measure into the Markov Decision Process framework. We then apply this framework to optimize the power system resilience.

57 - Coordination of a Multi-supplier and Single-manufacturer Supply Chain in Presence of New Technology Investment under a Stochastic Demand

Cesar Rodriguez, Concordia University, Montreal, QC, Canada, Qingguo Bai, Mingyuan Chen

This work explores the impact of technology investment on supply chain coordination. To be specific, we investigate the optimal pricing and technology investment decisions in a system consisting of multiple complementary suppliers and a single manufacturer. We compare both the decentralized and centralized settings, and show that if the supply chain members decide to cooperate and coordinate the system, they could increase the overall expected profit by at least 1/3. We then find that the cost-revenue sharing contract is capable of coordinating the supply chain. Moreover, we establish the conditions at which this contract offers a win-win profit scenario to all parties of the negotiation.

58 - A Novel Feature Selection Algorithm for Continuous Response Prediction with Interacting Variables

Maryam Nikouei Mehr, Iowa state university, Ames, IA, United States, Sigurdur Olafsson

This paper concerns a new feature selection method for multiple linear regression models. While common feature selection methods focus on the removal of redundant or irrelevant features, we show that such features may be important. We establish a computational framework for selecting a subset of features that have significant interactions with the response and a subset of features that may have little interactions with the response, but when combined with others, they can be strongly predictive of the response. Removal of these features can thus result in poor predictions. A mixed integer linear programming model is implemented to recognize feature interactions and their exact combinations.

59 - Pricing Problem for a Product with Network Effects and Multiple Demand Segments

Fatemeh Nosrat, Univeristy of Minnesota-Twin Cities, Minneapolis, MN, United States, nosra002@umn.edu

We consider a pricing problem for a product that experiences network effects. We assume that there are multiple segments of buyers, and individuals' intrinsic values for the product and sensitivities to the network effect vary across segments. Demand is described by the Mixed Multinomial Logit model, modified to incorporate network effects. We formulate and analyze an optimization problem that aims to find the seller's revenue-maximizing price. In settings with an arbitrary number of demand segments, we present a simple, effective heuristic solution approach. In settings with two segments, we obtain a solution method that outputs near-optimal prices.

60 - Adaptive Cluster Sampling-based Approximation for Two-stage Stochastic Programs

Siavash Tabrizian, Southern Methodist University, Dallas, TX, United States, stabrizian@smu.edu

We present an adaptive clustering based sampling technique for two-stage stochastic programs, and we discuss its performance for estimating the recourse function. We also present a decomposition algorithm design for solving two-stage stochastic programs and demonstrate its efficiency through numerical experiments on classical test instances.

61- Deep Inverse Optimization

Yingcong Tan, PhD Candidate, Concordia University, Montreal, QC, Canada, Andrew Delong, Daria Terekhov

We propose a framework for inverse optimization based on deep learning by treating an interior point solver as a deep differentiable computational process. Given a set of observations from an unknown linear optimization process, we can learn LP model parameters consistent with those observations, facilitating prediction of optimizing agent behavior.

62 - Conditional Supervalid Inequalities for Graph Interdiction Problems

Ningji Wei, University at Buffalo, SUNY, Buffalo, NY, United States, ningjiwe@buffalo.edu, Jose Luis Walteros

We focus on attacker-defender network interdiction problems in which: (1) the objective minimizes the attacker's cost of achieving a certain disruption level over the defender's problem; (2) the defender's problem is to select an optimal graph structure (e.g., a shortest path, a spanning tree) over the residual graph; (3) the attacker strategies are defined over the same ground set of the defender's graph structures. We develop a cut-generating framework that produces a general class of supervalid inequalities that remove non-trivial suboptimal solutions. We show how to adapt the proposed framework to tackle a wide variety of theses problems.

63 - A Patient No-show Predictive Model with Limited Data and Information for Outpatient Appointments

Fangzheng Yuan, North Dakota State University, Fargo, ND, United States, Fangzheng.yuan@ndsu.edu, UGPTI, Fargo, ND, United States, Fangzheng.yuan@ndsu.edu, Joseph Szmerekovsky, Vera Tilson

No-shows is one of the most common and challenging issues for appointment scheduling. However, it is not always able to obtain the data and information wanted in order to predict patients' no-shows due to some business, privacy, and ethical reasons. In this study, we developed a decision tree model for predicting the no-show probability of outpatient appointments for a medical center and compared it with few commonly used models in related topic. This study demonstrates an alternative way to predict patient's no-show probability based on limited data and information and has been proved to be effective with a high R-square value.

64 - Knowledge Discovery From Patient Experience Surveys through Text Mining

Mohammadsadegh Mikaeili, Binghamton University, Binghamton, NY, United States, mmikaei1@binghamton.edu, Sarah S. Lam, Joshua Bosire, Jady Yao

Unstructured data in healthcare can be utilized to develop intelligent models to improve operations. One source of such data is the unprocessed textual data in form of surveys completed by patients after they receive their care. The mechanism for collecting unstructured feedback from patients has become commonplace, however, analysis techniques have not been frequently applied to examine this data source. This research utilizes text mining on free-text feedback to evaluate patients' perception of service quality and to use this insight to identify inefficiencies. The proposed methodology explores the analysis of textual commentary using an unsupervised learning (topic modeling) procedure.

65 - Precipitation Prediction Based on Historical Data Using the K- Nearest Neighbor Method

Sean C. Guidry Stanteen, Research Assistant, University of Texas at Arlington, Arlington, TX, United States

Weather, particularly precipitation, is an environmental condition on which agriculture is wholly dependent. As such, prediction on precipitation and other weather factors is essential to proper farming management. A data science method, K-Nearest Neighbor (KNN), is utilized to matches up historical patterns for short term prediction, and preliminary data testing shows the validity of the methodology. This work is in collaboration with Dr. Xunchang John Zhang, Dr. David Brown, Dr. Jianzhong Su, and USDA-ARS Grazinglands Research Laboratory, El Reno, Oklahoma.

66 - Adaptive Spaces and Real-time Emotive Prediction Using Unobtrusive Wearable Devices for Personalized Healthcare.

Mona Ghandi, Washington State University, Pullman, WA, United States, mona.ghandi@wsu.edu, Marcus Blaisdell

Personal automatic emotional classification analytics can offer a new diagnostic tool that allows personalized medical care and helps researchers to find patient-specific information that would be difficult to spot with traditional research methods and often times more quickly and cost effectively. We have developed a method that can provide automatic real-time emotional state determinations out of the laboratory. The use of wearable sensors in conjunction with mobile connectivity combined with machine learning techniques allow us to move this technology out of the laboratory and into real-world applications in smart adaptive environments to improve users' mental health and well-being.

67 - A Hierarchical Model of the Federal Funds Market

Saurav Chakraborty, Doctoral Candidate, University of South Florida, Tampa, FL, United States, sauravc@mail.usf.edu, Don Berndt, David Boogers

The Great Recession (2007-2009) had profound impact on the US Federal Reserve (FR) system. In response to the crisis, the FR took unprecedented action. In particular, the Fed responded by lowering the target Federal funds rate, granting credit to financial firms, and eventually engaging in a series of large scale asset purchase programs comprising quantitative easing (QE). As the FR seeks to unwind its positions, the impacts of monetary policy normalization (MPR) are uncertain. We propose a framework using agent-based modeling and simulation to better understand and evaluate policy alternatives. In particular, a hierarchy of coarse-grained and fine-grained models are used to simulate MPR.

68 - Implementing KIER's Basic RND Project Assessment Based on Technology Readiness Level for Managing RND Projects Efficiently

Seongkon Lee, Principal Researcher, Former Head, Korea Institute of Energy Research, Daejeon, Korea, Republic of, sklee@kier.re.kr

Korea Institute of Energy Research(KIER) has been carrying out strategic energy RnD projects for addressing the national energy agenda. KIER receives basic RnD funds from the Government annually and budget in 2019 accounts for 146 million USD. This research changes the previous basic RnD assessment method focused on the achievement of technical targets to Technology readiness level(TRL) assessment approach classifying each level's technical target clearly. In addition, technical status table, including TRL and current status of the global leading research institute or company, is added in proposal. This research will enhance the management of KIER's basic RnD funds more efficiently.

69 - Optimum Design of Blood Pressure Telemonitoring Systems for Hypertensive Patients

Sulki Park, Texas A&M University, College Station, TX, United States, sulkipark828@tamu.edu, Hye-Chung Kum, Mark Lawley

Blood pressure (BP) telemonitoring offers hypertensive patients the opportunity to obtain early clinical intervention and cost-effective care. Using a telemonitoring company data, we analyzed the number of non-clinical staffs, who followed up with patients to get daily BP readings, and clinical staffs, who followed up with abnormal BP readings, as well as time consumed for the supports, to provide scheduling insights of telemonitoring support services. Through these results, we can help to develop an optimal program of telemonitoring support system, including the optimal number of clinical and non-clinical staffs, and the effect of procedure length on patients' health outcomes.

70 - Hedge Modelling for Solar Power Business Using Multiple Non-parametric Regression Methods

Takuji Matsumoto, PhD candidate, University of Tsukuba, Tokyo, Japan, s1745014@s.tsukuba.ac.jp, Yuji Yamada

The large-scale introduction of natural energy being promoted worldwide in recent years leads to an increased impact of weather fluctuations on wholesale electricity prices. Under such circumstances, hedging needs for revenue fluctuations in the solar power business have been expanding. Therefore, this work proposes hedging strategies for the power companies, using a portfolio of derivatives with fuel price, solar radiation and temperature as underlying assets. We specifically propose a hedging method that applies multiple non-parametric regression methods such as tensor product spline and ANOVA decomposition and demonstrate the hedge effect using empirical data from the Japanese market.

71 - A Time Series Clustering Based Customer Segmentation Framework for Predicting Account Behaviors

Xingwei Yang, PhD student, Queen's University, Kingston, ON, Canada, xingwei.yang@queensu.ca, Matthew Thompson, Akram Khaleghei Ghosheh Balagh, Mikhail Nediak

For many applications, banks need to classify customers into groups of individuals with shared characteristics. Traditional customer segmentation intuitively segments the customer using sets of predefined information such as age, gender, geographic information and etc. We present the design of a customer segmentation framework based on time series clustering from the account balance activities of customers through time. We demonstrate how the clustering of account behaviors can improve the prediction of the expected lifetime of each dollar deposited to the bank and monitor the expected duration and the total amounts of the investments the bank can fund.

72 - Optimizing the Biorefinery Supply Chain: Impact of Feedstock Quality on Logistics Design

Yingqian Lin, Postdoctoral Researcher, Idaho National Laboratory, Idaho Falls, ID, United States, yingqian.lin@inl.gov, Pralhad Burli, Damon Hartley, Roni Mohammad, Mike Griffel, David N. Thompson

Biomass is known to be a raw material as it can be used in a variety of applications for the production of bioenergy and bioproducts. We propose a novel mixed-integer linear programming (MILP) model to find the maximum number of biorefining facilities that could be supported based on estimates of available crop residue and dedicated energy crops.

73 - Eco-efficiency Assessment of U.S. Tourism Industry Using the EIOLCA and DEA Framework

Yong Shin Park, St.Edward's University, Austin, TX, United States, Myungwoo Lee, Hyelin Kim

This study proposes an EIO-LCA and DEA based eco-efficiency assessment for the U.S tourism sector considering direct and indirect impacts. Results indicated that other amusement and recreation industries and bowling centers were found to have the most significant shares in environmental impact. Based on supply chain decomposition analysis, there was a high environmental impact across the supply chain for each tourism industries. Based on DEA analysis results, the average eco-efficiency score of U.S tourism industry is found to be 0.47 meaning that inefficient U.S tourism industries need to reach an average reduction of 53% on the environmental impact to reach 100% eco-efficiency frontier.

74 - A Joint Ordering and Markdown Policy for Perishable Products with Fixed Lifetime

Zheng Wang, Southeast University, Nanjing, China, wangz@seu.edu.cn, Xue Qiao

For perishable products with fixed lifetime, we study the joint ordering and markdown problem based on the two-shelf (i.e., fresh product shelf and less fresh product shelf) management rule, in the situation that demand depends on price and freshness and unsatisfied demand is lost. Firstly, for the single-period case, we consider the inventory levels for products at different shelf-ages and obtain the optimal analytic solution by using the KKT-condition. Secondly, we extend the one-period decision to a myopic policy and apply it to the multi-period case. Numerical experiments show that the proposed joint ordering and markdown policy performs better than the traditional one-shelf management rule.

75 - Designing a Data-driven National Research and Development Budget Allocation Model

Hoon Jang, Korea University (Sejong Campus), Sejong, Korea, Republic of, hoonjang@korea.ac.kr

Since research and development (R&D) has been proven to be a key driver of economic growth, the volume of R&D budgets has been growing in many countries. This requires decision makers to determine the right number of R&D projects and optimally allocate budgets. Motivated by this, in this study, we propose an integrated model which assists decision makers to select and distribute R&D budget effectively. Specifically, we offer a way of allocating R&D budgets in order to maximize the total expected outputs from R&D projects. Experimental results confirm that our approach can help improve the entire of R&D budget allocation process.

76 - Tuning Deep Flooding Risk with Adaptive Strategy: An Application for NYC

Kairui Feng, PhD Student, Princeton University, Princeton, NJ, United States, kairuif@princeton.edu, Ning Lin

The impact of the storms worsens in the coming decades due to the rapid development of the coastal zone in conjunction with sea-level rise and possibly increased storm activity due to climate change. We develop a reinforcement-learning-based strategy of adaptive seawall design, to cope with the deep uncertainty in climate change effects by continuous observation and modeling. We apply this method to New York City and estimate its optimal adaptive seawall design. We show that the total lifetime cost is significantly reduced (by 20% to 40%; ~1 billion) when the dynamic, reinforced learning strategy is applied, compared to traditional design methods.

77 - Welfare Impacts of Optimal Virtual Bidding in A Multi-settlement Electricity Market with Transmission Line Congestion

Hyungkwan Kim, Lawrence Berkeley National Laboratory, Berkeley, CA, United States, hyungkwankim@lbl.gov, Paul V. Preckel, Douglas Gotham, Andrew Lu Liu

The objective of this research is to understand the effect of virtual transactions on electricity market efficiency using a model that explicitly includes the network as well as relationships that reflect the physical properties of electricity flows through a network (i.e. loop flow). The core research question is; what impact does network congestion have on the welfare shifts caused by the participation of financial virtual traders? Results indicate that optimal virtual bidding tends to decrease consumer welfare when the expected spot price is equal to the cleared forward price, and congested lines in the network can magnify the welfare changes while virtual traders essentially always benefit.

78 - Power Grid Resilience Planning for Extreme Weather Recovery

Priyadharshini Kumaravelan, Masters in EE, Texas State University, San Marcos, TX, United States, p_k41@txstate.edu

The traditional N-1 power grid system is inadequate as it cannot withstand extreme weather events like hurricane, flooding, earthquake etc. Extreme event analysis reports by NERC, BPU, ERCOT state that failure of outdoor grid components like transmission lines, transformers and generators lead to majority of the power outages where millions of customers get affected. This paper addresses the problem of power grid resilience post an extreme weather event and how the grid recovery can be planned. We propose a repair and recovery model for transmission lines for the case of Hurricane Harvey. We also present a Vehicle-to-Grid based resilience model for a manufacturing facility during an extreme event.

79 - Distribution Electricity Pricing under Uncertainty

Robert Mieth, NYU / TU Berlin, Brooklyn, NY, United States, robert.mieth@nyu.edu, Yury Dvorkin

Distribution locational marginal prices (DLMPs) facilitate the efficient operation of low-voltage distribution systems. We propose an approach to internalize the stochasticity of renewable resources and risk tolerance of the distribution system operator in DLMP computations. This is achieved by means of applying conic duality to a chance-constrained AC optimal power flow. We show that the resulting DLMPs consist of the terms that allow to itemize the prices for the power production, balancing regulation, and voltage support provided. Finally, we prove the proposed DLMP constitute a competitive equilibrium, which can be leveraged for designing a distribution electricity market.

80 - Regulatory Innovation and the Convergence of Electric Utility Policies: New Business Models and Electricity Market Design

Joseph Nyangon, Postdoctoral Research Scholar, University of Delaware, Newark, DE, United States, jnyangon@udel.edu

Several disruptive trends are driving energy transformation and forcing electric utilities to change their business models. The challenge for utilities is how to transition to "Utility 2.0" concepts: microgrid development, automated, distributed solar, electric market design innovations, smart grid systems, and big data and analytics. Using a multidimensional framework and case studies from United States (i.e., New York's REV, Illinois's NextGrid and California's Energy Savings and Performance Incentive), the U.K.'s RIIO, Germany's Energiewende, and Australia's Electricity Network Transformation Roadmap, this study examines electricity market design and flexibility innovations.

81- Development of Customer DNA Database in a Gas Company

Noriko Furuta, Tokyo Gas Co Ltd, Minato-ku, Japan, noriko.furuta@tokyo-gas.co.jp

Personalized customer experience has become more important in Japanese energy retailers. In this study, we constructed models to estimate customer attributes, lifestyles, and values from our data by machine learning, and developed "customer DNA" database. By using this database, we can improve response rate of marketing actions by 16-23%.

82 - Online Readiness in undergraduate Students

Sara Hooshangi, The George Washington University, Washington, DC, United States

The purpose of this study is to examine the online readiness characteristics of undergraduate students majoring in an information technology program. Computer, internet, online communication self-efficacy, self-directed learning, and learner control were measured. The result showed that students' level of self-efficacy in using online tools was very high. The learner control was low and self-directed learning was moderate among these students. Comparison between gender and different age groups showed no significant differences in online readiness factors among these groups.

83 - Normalization Strategies and Development for Improved NCAA Basketball Tournament Predictions

Jessica M. Rudd, PhD Candidate, Kennesaw State University, Kennesaw, GA, United States, jess@irudd.com

The study utilizes various normalization techniques for NCAA basketball tournament prediction. Baseline models using tournament seeds, several popular sports ranking methods, regular season game statistics, and tournament results, dating back to 1985 where available, are compared with results using several normalization strategies, including approaches not known to be tested on this problem as well as a novel season rank-based approach. Baseline models predicted previous tournament wins with accuracy as high as 76%. Normalized model brackets performed as high as 97% accuracy in the 2019 tournament.

84 - Staffing Level in Optimization Service Systems

Mohammad Maydanchi, Graduate Research Assistant, Auburn University, Auburn, AL, United States, Samira Shirzaei

Waiting time is one of the important factors in queuing theory. To have a less waiting time, more staffs are needed, however, extra staffs can be expensive. Thus, managers prefer to have an optimal balance between these two elements. We developed a user friendly GUI tool in Excel using VBA. This tool aims to simulate the queuing system to achieve the optimal number of required staffs.

85 - Gradient Based Criteria for Sequential Experiment Design

Bruce Ankenman, Northwestern University, Evanston, IL, United States, ankenman@northwestern.edu, Collin Erickson, Matthew Plumlee, Susan Sanchez

Computer simulation experiments are commonly used as an inexpensive alternative to real-world experiments to form a metamodel that approximates the input-output relationship of the real-world experiment. While users may want to understand the entire response surface, they may also want to focus on interesting regions of the design space, such as where the gradient is large. We present a batch sequential algorithm that adaptively runs a simulation experiment that focuses on finding areas of the response surface with large gradient while also gathering an understanding of the entire surface. The design points within each batch can be run simultaneously.

86 - Latent Variable Model with Embedding Structure

Xiexin Liu, Tippie College of Business, Iowa City, IA, United States, xiexin-liu@uiowa.edu

Finite mixture model assumes observed instances are from a mixture of K component distributions. It is often of applied researchers' interest to understand the practical meaning of the mixture components, e.g., topics in Latent Dirichlet Allocation. However, like most statistical models, finite mixture model assumes independency among variables, which is not the case in most real-world problems and could identify false components following this assumption. To this end, we extend finite mixture models to incorporate an embedding structure, where we consider variable interaction when identifying the underlying mixture components. We use variational inference to solve for the proposed model.

87 - Simulating the Impact of Multiple-region Listing and Information Sharing on Kidney Transplant Outcomes and Discard Rates

Zahra Gharibi, State University Of New York at Plattsburgh, Plattsburgh, NY, United States, zghar001@plattsburgh.edu

New kidney allocation system and modern IT solutions are developed to improve kidney assignment. We develop a simulation model that considers the effect of several important factors for organ transplantation affecting kidney utilization. We investigate how the optimal individual-level acceptance decisions are affected by the difference in supply in different transplantation regions. We also focus on a macro-level aspect of transplantation, namely the contribution of information sharing on the social welfare and discard rates.

88 - Deterrence As Target Shifting in Layered Cyber Defense: A Behavioral Analog Game

Sarah Kusumastuti, Center for Risk and Economic Analysis of Terrorism Events (CREATE), Los Angeles, CA, United States, kusumast@usc.edu, Jim Blythe, Heather Rosoff, Richard S. John

This study examines how exploiting biases in probability judgment can enhance deterrence using a fixed allocation of defensive resources. We designed and conducted a behavioral experiment functioning as an analog cyber-attack with multiple targets requiring three stages of attack to successfully acquire a target. Participants play as cyber attackers choosing between target types with different resource allocations but approximately equal overall success rate for all targets. We collected data from a total of 1600 separate target selections from 80 players. The findings are consistent with both anchoring and ambiguity biases and an interpretation of failed attacks as near misses.

89 - Theoretical Constructs for Assessing the Long-term Effectiveness of Airport Infrastructure Interventions

Bortiorkor Nii Tsui Alabi, Purdue University, West Lafayette, IN, United States, Julius Keller, Samuel Labi

Airport infrastructure maintenance intervention effectiveness can be measured in terms of infrastructure longevity, cost-efficiency, profitability, safety, and mobility. With regard to these performance criteria, this study presents theoretical constructs that utilize their respective performance functions to measure intervention effectiveness. These measurements will assist airport managers assess the success of physical or operational interventions, and thus help them monitor airport infrastructure performance.

90 - Hotspots: Real-time Driver Navigation Guidance via Reinforcement Learning

Hao Yi Ong, Lyft, San Francisco, CA, United States, hong@lyft.com

While experienced drivers can rely on their knowledge of historical demand to guide their driving, newer drivers suffer from relative inexperience. Hotspots are the Lyft driver's real-time navigational aid for where to drive to maximize long-term driver earnings subject to uncertainty in the supply and demand distributions. The algorithm generates a value heatmap with suggested peaks unique to each driver, and is based on learning offline estimates of the value of driving at specific times and places and fusing it with online estimated travel times and demand and supply forecasts to produce real-time value estimates.

91 - Research on Coordinated Development of Inland Port and Seaports under the Background of the Belt and Road

Jingying Yang, National United Engineering Laboratory of Integrated and Intelligent Transportation, Chengdu, China, 1457146422@qq.com, Southwest Jiaotong University, Chengdu, China, 1457146422@qq.com, Yinying Tang

With the promotion of the Belt and Road strategy, the problems arising from the coordinated development of inland ports and seaports have gradually become prominent. Based on the idea of system dynamics, this paper constructs a dynamic model of collaborative development between inland port and seaports, and simulates the system dynamics by changing some factors in the system. The simulation results show that the investment in the port of the sea has the most obvious effect on the development of the system. Improving the port's ability to pass and strengthening the smoothness of the interconnection channels within the system have some promotion on synergistic development.

92 - Optimization of High-speed Railway Network Based on Accessibility of Stations

Jinqu Chen, Southwest Jiaotong University, Chengdu Sichuan, China, Chenjinqu@my.swjtu.edu.cn, Yong Yin

The optimization of High-Speed Railway (HSR) network is studied. Based on the stations' degree, stations' clustering coefficient and other indicators, the topology characteristics of China's HSR network in 2030 are analyzed. The LeaderRank algorithm is used to identify the key stations of HSR network. Then the optimization model is established and solved with the goal of optimal accessibility of global network. The result shows that Changsha is the most important station in China's HSR network in 2030. Considering the investment restrictions of railway construction, constructing HSR links in Northeast and North of China can maximize the global accessibility of China's HSR network in 2030.

93 - Research on Collection and Distribution Optimization of Chengdu International Railway Port Based on Genetic Algorithms

LuLu Liu, Southwest Jiaotong University, Chengdu, China, 990972547@qq.com, National United Engineering Laboratory of Integrated and Intelligent Transportation, Chengdu, China, 990972547@qq.com, YinYing Tang, Si Chen

Taking the transportation cost of the whole network as the objective function and the time requirement of the shipper, the capacity limitation of nodes and edges as the conditions, the model is constructed to meet the minimum transportation cost of the whole network. The priority-based piecewise encoding inverse method is used for encoding, and the elite strategy is used to solve the model. Finally, the model is used to collect and disperse Chengdu International Railway Port.

94 - The Value of Halal in the U.S. Market Implications for the Logistics Industry

Neeraj Dhingra, North Dakota State University, Fargo, ND, United States

Halal is adherence to Islamic Sharia dietary laws mostly practiced by Muslim communities. Demand for halal meat is growing rapidly in the US primarily because of the rapidly growing Muslim population which is expected to increase to 8.1 million by 2050, and availability of agricultural and livestock resources. The objective of the study is to examine the determinants that could influence customer willingness to pay for halal logistics services. Consumer Willingness to pay analysis for halal food logistics is an essential attribute for understanding customer response to halal supply and determining the corresponding change in the logistics industry.

95 - Recognition of Critical Nodes in Emergency Transportation Network Considering Random Node Failure of Natural Disasters

Si Chen, Southwest Jiaotong University, ChengDu, China, chensi@swjtu.edu.cn, National United Engineering Laboratory of Integrated and Intelligent Transportation, Chengdu, China, Xiaozhen Deng, Yinying Tang

Combining PageRank and Warshall to establish the algorithm identifies key nodes in different stages under random failure of nodes to identify key nodes and isolated key nodes in transportation network under natural disasters. Based on the premise of maximum natural disasters and greedy strategy, this paper takes the critical transportation network of Wenchuan earthquake as an example, the results of key transportation network nodes are accurate. The algorithm can detect the key nodes of transportation network dynamically in real time, and provide theoretical basis for material transportation and personnel evacuation in the rescue process.

96- Potential Transfer Station Selection Using Integrated Development of Rail Transit Nodes and the City in a Metropolitan Area

Siyu Tao, Southwest Jiaotong University, Chengdu, 610031, China, National United Engineering Laboratory of Integrated and Intelligent Transportation, Chengdu, China, Xinmei Chen, Tao Feng, Qiyuan Peng

Integrated development of transit nodes and the city (ITCD) is a new concept based on the Transit-Oriented Development (TOD). Reasonable integrated planning the transport facilities with the city is also significant in improving the interaction between transit and the surrounding development. Therefore, we propose a methodology to quantitatively measure the ITCD degree of the exist rail transit nodes. The value of the ITCD degree indicates the current level of the stations, which will help find out the specific characteristics or functions should be improved for a better integrated development of stations and the city.

97 - Logistics Network Layout Design for E-commerce Demand in Remote Mountainous Areas- A Case Study of Aba Prefecture

Zhaoyi Xie, Southwest Jiaotong University, Chengdu, China, 346072525@qq.com, National United Engineering Laboratory of Integrated and Intelligent Transportation, Chengdu, China, Si Chen, Yinying Tang

According to the characteristics of E-commerce in remote mountainous areas, this paper carries out factor analysis and cluster analysis on logistics nodes to select first-level nodes and second-level alternative nodes.Taking the minimum annual total cost as an objective function,the optimization model of location selection of logistics network nodes in remote mountainous areas is constructed.Finally this paper takes 13 counties and municipalities of Aba Prefecture as the object of study,and obtains the three-level logistics network which provides theoretical basis for the development of e-commerce logistics in Aba Prefecture.

98 - Street-level Travel Time Estimation Using Data from Uber Movement and OpenStreetMap

Kelsey Maass, University of Washington, Seattle, WA, United States, Pacific Northwest National Laboratory, Richland, WA, United States, Arif Khan, Arun Sathanur

Data-driven transportation modeling forms an important part of modern urban planning. We propose a method for estimating street-level travel times from data aggregated over traffic analysis zones. Using data for the Los Angeles region from Uber Movement and OpenStreetMap, we present a workflow for 1) obtaining and preprocessing data, 2) estimating street-level travel times using a combination of graphical models and optimization methods, and 3) validating results using a variety of metrics.

99 - Adjusting Departure Time for Reducing Power Consumption of MRT Railways

Kyung Min Kim, MyongJi University, Yongin-si, Korea, Republic of, kmkim@mju.ac.kr

As regenerative power produced when train braked can be used by other accelerating trains within a specific range of the power supply system, it is possible to reduce power consumption. This paper considers the problem of adjusting train departure time to reduce power consumption of mass rapid transit (MRT) railways. We formulated the problem as mixed integer program and developed genetic algorithm (GA) to solve the problem. To validate the suggested GA, a computational experiment was conducted using data generated by a simulator. Applied to the current daily timetable of the Gwangju Line 1, we could find a practical solution, which is an about 4% improvement over the current timetable.

100 - A Heuristic Approach for Improving Utilization in Micro-Mobility Systems with Crowd-Sourced Resupply

Lacy Greening, Georgia Institute of Technology, Atlanta, GA, United States, Alan Erera

The rapid growth of shared micro-mobility systems has resulted in idle bikes and scooters overcrowding sidewalks across the United States. We present simulation-based heuristic approaches for distributing vehicles in an effort to improve the utilization of a shared, free-floating, electric micro-mobility fleet that relies on daily crowd-sourced charging and relocating. An integer programming model of the system is used to identify trends in distribution plans and determine a good sample-average upper bound on the expected number of trips served by a given fleet size. This upper bound is then used to assess the quality of distribution plans determined by different variants of the core heuristic.

101 - Exploring Time Variants for Short-term Metro Passenger Flow Based on EEMD with Data Characteristic Analysis

Lan Liu, Southwest Jiaotong University, Chengdu, China, jianan_l@home.swjtu.edu.cn, Hao Huang, Jiannan Mao

To explore time variants of short-term metro passenger flow, the ensemble empirical mode decomposition (EEMD) with data-characteristic-driven reconstruction is proposed in this paper. Firstly, the EEMD is employed to decompose the original data into several intrinsic mode functions (IMFs) and a residue. Besides, a data-characteristic-driven method is introduced to reconstruct the IMFs into meaningful components. Finally, the proposed model is tested on the real short-term passenger flow data in Chengdu, China. The results show that the proposed model is a promising method to analyze time variants for metro passenger flow because it can extract the inherent pattern of the passenger flow.

102 - Electric Vehicle Charging Station Daily Load Analysis with a Randomized Algorithm

Martin Trouilloud, Brown University, Providence, RI, United States, martin_trouilloud@brown.edu

The load on the power grid from electric vehicles (EVs) is continuously increasing. Applying queueing theory and the Monte Carlo method, we built a randomized algorithm to investigate the power output of an EV charging station. Combining stochastic (e.g. traffic rate) and non-stochastic (commuter data) phenomena, this interactive simulation allows for more accurate analysis of their impact on the grid.

103 - On the Application of Matrix Factorization for NYC Traffic Pattern Recognition

Marzieh Abolhelm, University of Illinois at Urbana Champaign, Champaign, IL, United States, abolhel2@illinois.edu

Please check the mobile app for this abstract.

104 - New Data Visualizations Support Analysis of Vehicle Traffic at DFW Airport

Michael R. Hilliard, Oak Ridge National Laboratory, Oak Ridge, TN, United States, Hilliardmr@Ornl.Gov

We look at a collection of data visualizations as analytical tools to complement statistical and machine learning approaches. Integrating the visualizations into dashboards using Tableau software provides an interactive tool for exploration an discovery within a 20 million record data set of vehicle entry and exits at the Dallas Fort Worth Airport. The visualizations highlight seasonal, weekly, and daily temporal patterns for various types of traffic—parking, drop-off, employees, etc.. The poster is an opportunity to provide feedback to the researchers on the effectiveness of the visualizations.

105 - Text Mining Railroad Accident Narratives for Identifying Contributors to Railroad Accidents and to Extend the Sustainability of Fixed Field Data.

Neeraj Dhingra, North Dakota State University, Fargo, ND, United States

Identifying and evaluating the factors that contribute to rail accidents would help in developing prevention strategies. The FRA maintains historical data of railway accidents, including text description explaining the reasons for causing accidents in detail. Hence, understanding and evaluating the text would help in finding out responsible factors and extend the explanatory power of fixed field data. To achieve this goal, the author is applying advanced data mining techniques and association mining rules for evaluating the series of factors that contributes to accidents and financial losses.

106 - Vehicle Minimum Occupancy Standards for TNCs To Encouraging Ride Pooling

Paul Leiby, Oak Ridge National Laboratory, Oak Ridge, TN, United States, pleiby@gmail.com, Jonathan Rubin

Ride pooling (shared rides) and increased vehicle occupancy are key for achieving the full benefits of new mobility systems, including transportation network companies (TNCs) and automated vehicles. Incentives for ride pooling can limit congestion, energy use, and emissions by discouraging single or zero-passenger travel (deadheading). We evaluate flexible Minimum Occupancy STandards (MOSTs) to encourage higher vehicle occupancy (ride pooling). We utilize available data on TNC travel, analysis of ride pooling potential, and economic behavioral assumptions to benchmark a numerical model, and develop initial insights on the efficiency of pooling standards.

107 - Simulation on Signal Priority of Modern Tram Based on Anylogic —Case Study of Rong No.2 in Chengdu

Qi Liu, National United Engineering Laboratory of Integrated and Intelligent Transportation, Chengdu, China, yinyong@home.swjtu.edu.cn
Qi Liu, Southwest Jiaotong University, Chengdu, China, yinyong@home.swjtu.edu.cn, National Engineering Laboratory for Integrated Transportation Big Data Application Technology, Chengdu, China, Yong Yin

Modern tram follows a uniform signal at the intersection when it runs on urban roads. Its operation in semi-independent right of way affects the normal running of social vehicles to a certain extent. In order to research the time delay on other vehicles when modern tram is in semi-independent right of way, the intersection of Xiyuan Avenue and Piwen Road in Modern tram line (Rong NO.2) in Chengdu is simulated by Anylogic software. The simulation experiments are carried out on three kinds of control strategies. They are fixed signal timing, absolute signal priority and relative signal priority, respectively.

108 - Research on Diffusion Characteristics and Influencing Factors of Trucks in China Based on Freight Big Data

Qiujun Qian, Southwest Jiaotong University, Chengdu, China, 1006045506@qq.com, Mi Gan, Yuling Deng, Dandan Li

Mastering the characteristics of trucks diffusion and the main factors affecting the diffusion provide a preliminary basis fo China's highway capacity forecasting and freight regulation.Based on the data provided by the OFEX,we found (1) the empirical distribution of trucks transport distance basically presents a Normal distribution,(2)most drivers working only in a small area. (3) The number of unique provinces visited by more than 80% of trucks less than 10. A province can only attract up to 234 unique trucks. (4) The diffusion range of trucks was basically stable after about 4 weeks. (5) Possibility of each truck transfer is strongly influenced by the province's freight volume and GDP.

109 - How to Allocate Lanes on Urban Roads in the New Era of Mixed Traffic with Autonomous Electric Vehicles and Human-driven Vehicles?

Rui Ma, Assistant Professor, The University of Alabama in Huntsville, Huntsville, AL, United States, Rui.Ma@uah.edu, Jingjing Liang, Michael Zhang, Xiaoning Zhang

We investigate the lanes allocation problem in mixed traffic of human-driven vehicles and Autonomous electric vehicles(AEVs) with the aim of jointly minimizing the total travel time and the total life-cycle greenhouse gases emissions, then identify critical links that are really necessary to build dedicated lanes in the long run by analyzing the optimal solutions under different levels of market penetration of AEVs. A bi-objective programming model with equilibrium constraints is proposed for describing the lanes allocation problem. A solving algorithm is also developed and computational results are provided.

110 - Strategic Decision of Determining Air Taxi Network Infrastructure Locations Using an Iterative Constrained Clustering Approach

Suchithra Rajendran, Assistant Professor, University of Missouri, Columbia, MO, United States, Joshua Zack

This study is one of the first to estimate the demand for air taxi aviation services and provide recommendations on the potential infrastructure locations to support the network operations. We adopt a two-phase approach: first phase estimates the demand for this market by taking a subset of the regular taxi customers based on several parameters, and second phase proposes a constrained clustering approach, with multimodal warm start technique, to identify potential infrastructure sites based on the estimated demand from the first phase. We test the feasibility of the proposed approach using the millions of real-life New York City taxi records.

111 - Bike-sharing Operations

Qiuzhuang Sun, National University of Singapore, Singapore, Singapore, q_strong@163.com

Tuesday, 2:00PM - 3:30PM

■ TD01

CC- Room 201

Applications of Data Mining in Supply Chain Management

Sponsored: Data Mining

Sponsored Session

Chair: Phillip Howard

1 - Reinforcement Learning Versus Optimization

Seho Kee, Arizona State University, Tempe, AZ, 85044, United States, skee4@asu.edu, Ghazal Shams, Jan Buchmann, Mani Janakiram, Sangbum Lee, Jonathan Tan, Mark A. Wilkinson, George Runger

Reinforcement learning has earned huge interest recently due to its successful applications in many domains. However, investigation on its performance has gained less research interest. In this presentation, we evaluate the effectiveness of reinforcement learning and compare with optimization solutions.

2 - Applications of Machine Learning to Supply Chain Forecasting & Inventory Management

Phillip Howard, Intel Corporation, Chandler, AZ, United States, Joshua Quine Hale

While methods for forecasting and inventory management in supply chains are well-established, many of these traditional approaches can be improved upon through application of machine learning techniques. In this presentation, we will discuss how methods such as cross validation and ensembles can improve upon the performance of time series models commonly used for forecasting. Additionally, we will show how traditional approaches which treat forecasting and inventory management as separate modeling tasks are sub-optimal. Methods for integrating forecasting & inventory management in order to improve the overall performance of the business process will be explored.

3 - Forecasting Customer Returns

Aysegul Demirtas, Intel, Chandler, AZ, 85281, United States, Aysegul.Demirtas@asu.edu, Zhenying Zhao, Vivian Zheng, Shamin Shirodkar

Intel has a high ranking among the most complex supply chains around the globe. In this project, our goal is to increase the forecast accuracy of returns at depots from different continents. We present the detail descriptive analytics on customer returns and predictive models that we built to increase accuracy.

4 - Hunting for Phantom Inventories

Sergio A. Caballero Caballero, Massachusetts Institute of Technology (MIT), Cambridge, MA, United States

In this paper we use machine learning techniques to detect phantom inventories at customers' retail stores for a major CPG manufacturer. We leverage daily point-of-sales, inventory on-hand, and audit data at a SKU-level in more than 400 stores. Our approach provides timely and more accurate predictions compared to existing solutions.

5 - Assessing and Mitigating Supply Request/Response Variability Using Advanced Data Analysis

Sean Cunningham, Supply Chain Professional, Intel Corporation, Santa Clara, CA, United States, sean.p.cunningham@intel.com, Alison Friday

Intel plans and procures components manufactured by a vast world-wide network of original design manufacturers (ODMs). These ODMs perform work in serial manufacturing stages, including fabrication, assembly, product test, etc. We present analytics for assessing the within-cycle and cycle-over-cycle variability of Intel's supply planning build request to these ODMs. We review findings from multiple ODM manufacturing stages, and we determine root causes for supply chain build request variability. We review Intel's work to reduce this variability, and to show improvement in the overall performance in ODM accept rate for Intel's build requests.

■ TD02

CC- Room 202

Industrial Applications of Data Science

Sponsored: Data Mining

Sponsored Session

Chair: Guang Yang

1 - The Power of Analytics - Improve Nuclear Power Plant Operations and Maintenance

Charlotte (Pu) Wang, Lead Data Scientist, Duke Energy, Charlotte, NC, United States

Power plants have huge amount of data stored in their control and monitoring systems. In this paper, we showcase a recent analytics practice which turns data into actionable information, hence greatly improves plant O&M. The challenge is to identify failed seal in the Reactor Coolant Pump (RCP) in a nuclear generation unit. The traditional diagnose process is manual and tedious, accuracy is also questionable. A regression-based model is developed to provide timely and accurate diagnose. With a conveniently designed web-based application, model tuning and data analysis is automated, interactions are directly between nuclear engineers, with no intervene required from data scientists.

2 - Integrating Graph-based Structure and Time-series in Demand Forecasting

Bo Zhang, PhD, Alibaba Group, Bellevue, WA, United States, Zhongjun Zhang

Due to the availability and expense, the amount of data is not always sufficient for deep learning based forecasting. Furthermore, since there exists a demand of interpretability, a linear closed-form is the first choice in many situations. However, this is incompatible with data volatility and accuracy requirement. In this talk, we propose a graph-based approach for demand forecasting. First, metrics are defined based on demand characteristics, then embedding methods are applied to represent the graph structure. In addition to commonly used error metrics, we also consider inventory features. The effectiveness of this method is demonstrated on the demand forecasting of Alibaba's IoT Products.

3 - Simulation Framework and Algorithms for Route Tickets Assignment in Fulfillment Center

Guang Yang, Jet.com/Walmart Labs, Hoboken, NJ, 07030, United States, guang@jet.com

In e-commerce business, customers online orders will be batched into route tickets, and then associates will hold a cart to pick items scattered in the fulfillment center for these orders. It is desired to batch these orders in a way that associates overall travel distance is minimized given the limited cart space and required completion time. This is a complicated problem that involves bin packing, vehicle routing, and job scheduling problem. In this study, we built a simulation framework and algorithms for this route tickets assignment problem. We show that a greedy approach based on additive route path can drive down the travel distance by 27%-35%, comparing to the chronological assignment baseline.

5 - Content Navigation

Xugang Ye, Seattle, WA, United States

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■ TD03

CC- Room 203

Joint Session DM/Practice Curated: Data Mining and Advanced Analytics Applications in Supply Chain

Sponsored: Data Mining

Sponsored Session

Chair: Manjeet Singh

1 - Solving Slotting and Order Batching Problem Using Data Mining and Heuristics

Siqiang Guo, Senior Solutions Design Analyst, DHL Supply Chain, 570 Polaris Pkwy, Westerville, OH, 43082, United States, siqianggeorgeguo@gmail.com

Picking is the most labor intensive activity in order fulfillment warehouses. A powerful and flexible order batching algorithm plays a key role in meeting customers' high service level requirements with low labor costs. However, intelligent batching of orders could be compromised by a sub-optimal slotting strategy . That's why an efficient slotting method is an indispensable part of a comprehensive solution to improve the picking efficiency.This research solves a real example which demonstrates the efficacy of the proposed hybrid approach, based on data mining and constructive heuristics, in solving the slotting and order batching problem.

2 - Continuous Cost Oriented Carton Optimization for eCommerce Operations

Bocheng Yu, DHL Supply Chain, Westerville, OH, 43082, United States, max.yu@dhl.com

Nowadays, eCommerce orders are delivered in cartons. Due to dimensional weight charge, the size of carton plays significant role in shipping cost. Although make-to-order packaging machine can reduce shipping cost, it has limits such as space requirement and complexity. Thus, most warehouses stock different sizes of pre-made cartons. However, the sizes of eCommerce orders are infinite, leading to the question, i.e. which carton sizes and how many should a warehouse store to minimize shipping cost. This research shows application of machine learning and meta-heuristic to (a) find out near optimal array of cartons and (b) monitor and update carton sizes based on changing order profiles.

3 - Network Mode Optimization for DHL Supply Chain

Yibo Dang, Ohio State University, Columbus, OH, United States

DHL Supply Chain North America moves more than twenty million packages each year. As one of the largest third-party logistic providers, DHL Supply Chain perform routing and cost deduction tasks for many large-scaled business projects. The objective is to diagnose heterogeneous dedicated fleets and common carrier opportunities out of a half-million scheduled shipments, so that the overall transportation network costs are optimized. Unlike the ordinary Vehicle Routing Problems, the network optimization for DHL may require a power to solve this complex combinatorial problem fast. We formulate our problem with MILP, evaluated its tightness, provided an approximate decomposition-based procedure, and developed a so-called "Red-Black Ant Colony Meta-Heuristic" to solve the problem.

4 - Dynamic Decision Transportation Optimization

Manjeet Singh, DHL Supply Chain, Columbus, OH, 43230-9893, United States, manjeet.singhin@dhl.com, Jon Cox

Dynamic transportation optimization includes three optimization routines - Mode Selection Optimization, Pool Point Optimization and Round Trip Optimization. This session will explore the connection between freight savings and data analysis, weigh the business benefits of dedicated and private fleets, and show how applying freight optimization can lead to lower rates in both the truckload and LTL arenas.

5 - Solving the Uniform Case Pallet Loading Problem - A Case Study

Manjeet Singh, DHL Supply Chain, Columbus, OH, 43230-9893, United States, manjeet.singhin@dhl.com, Gan Du

The pallet loading problem (PLP) is generally tackled by attempting to maximize the number of boxes that can be loaded orthogonally on a pallet. Several methods have been proposed in the literature that focus on maximizing the volume utilization and stability of the pallet. In this research, a two-phase algorithm is proposed to solve a 3-dimensional PLP while considering humidity, and storage time. In the first phase, the boxes should fit completely within the pallet without any overhang. In the second phase, the number of horizontal layers per pallet is calculated based on pallet maximum height, max weight, and dynamic compressive strength of boxes.

■ TD04

CC- Room 204

Joint Session DM/Practice Curated: Data Mining & Analytics in Emerging Marketing Ecosystem – A

Sponsored: Data Mining

Sponsored Session

Chair: Ankur Jain

1 - Evaluating and Optimizing Campaign Strategy to Drive Brand Growth Through Lens of Multi-Touch Attribution

Diane Ma, Kantar, Lisle, IL, United States, diane.ma@kantar.com

Brand equity is critical in driving business outcomes. Campaigns effectiveness measurement needs to capture impact on both short-term sales and brand building, a multiplier on lower funnel business outcomes. While some attribution modeling approaches helps understand how channels and campaign strategies contribute to brand equity, multi-touch attribution approach (MTA), provides more granular insights on channel performance and efficiency of media strategy/tactics in driving incremental brand KPIs, and yield optimization opportunities of consumer targeting, frequency of exposures, and creative executions for future campaigns.

2 - Learning and Comparative Advertising: Evidence from Pharmaceutical Drug Detailing

Xiaojing Dong, Santa Clara University, Santa Clara, CA, United States, xdong1@scu.edu, Ying Xie, Pradeep Chintagunta

In this paper, we evaluate the impact of comparative messages on new product adoption, by developing a learning model with three distinctive features compared to the standard Bayesian learning framework, using data from a pharmaceutical category. First, we allow the information efficiency associated with the detailing visits to differ across message formats and brands. Second, we allow the comparative message from competing brands to jam the signals and disturb doctors' learning of the drugs' true qualities. Finally, we allow the doctors to forget the quality belief they've learned so far, due to the time elapsed since the last prescription.

3 - Campaign Identification Process for Marketing Mixed Model

Sepideh Pourazarm, Data Scientist, Nielsen, Needham, MA, United States, sepideh.pourazarm@nielsen.com, Mariappan Subramanian, Shweta B. Shah

Marketing Mix Modeling (MMM) aims at using statistical modeling to estimate effectiveness of media campaigns, based on historical sales and media data. Media data available for MMM is very granular and highly sparse making it un-fit to be used directly in modeling. Identifying the proper level of aggregation of media data is crucial for both model performance and stability. However, the process involves considerable manual intervention and analysis. In this paper, we propose a novel heuristic to automate finding effective definitions of marketing campaigns to enter the model that uses entropy-based approach for ranking media dimensions and a correlation analysis algorithm for collapsing them.

4 - Improving Survey Measurement Quality Through Geotargeting

Susruthi Vasudevan, Gartner, New York City, NY, United States, susruthi.143@gmail.com

Location is as valuable in the digital world as it is in the real world. Businesses are identifying customers and targeting them precisely when they enter storefronts. Given this sophistication for advertising, it's imperative to have the same knowledge incorporated into surveys to get better feedback and increased responsiveness. In this study, we explore a novel method to implement geo-targeting by identifying consumers when they are at locations where their time can be conveniently purposed towards a survey making the value proposition more attractive - motivating a more willing participation for a survey, and in turn, less straightlining and better quality of data.

■ TD05

CC- Room 205

Urban Traffic Management and Computing for the Era of Automated Transportation System

Sponsored: Data Mining

Sponsored Session

Chair: Pengfei(Taylor) Li, The University of Texas at Arlington

Co-Chair: Xianfeng (Terry) Yang, University of Utah, Salt Lake City, UT, 84112, United States

1 - Estimation of Queue Lengths and Traffic Volumes Using Probe Vehicle Trajectory Data

Yan Zhao, University of Michigan, Ann Arbor, MI, 48104, United States, zhaoyann@umich.edu, Jianfeng Zheng, Wai Wong, Henry Liu

The emergence of connected vehicle technologies and ride-hailing services has enabled the collection of probe vehicle trajectory data in large scale. The vast amount of trajectory data could become a substitute for the widely used fixed-location sensors in terms of the performance measures of transportation networks. This study proposes a series of novel methods for the estimation of queue lengths and traffic volumes at signalized intersections using the probe vehicle data. Validation results have shown that the proposed methods would be accurate enough for real-world applications.

2 - Signal Control and Autonomous Vehicle Trajectory Optimization for Enhancing Mobility

Lily Elefteriadou, Professor of Civil Eng., Director of UFTI, University of Florida, Gainesville, FL, 32611, United States

The presentation will discuss on-going work to develop optimization algorithms, simulation tools, and sensor capabilities for enhancing traffic signal control operations with connected vehicles, autonomous vehicles, and conventional vehicles. Early versions of the optimization were deployed and tested at the Traffic Engineering and Research Laboratory (TERL), a Florida Department of Transportation closed-course facility. The results from the field test confirmed the feasibility of the concept and are now used to enhance it for future testing and ultimately for field deployment. The research, led by UF, is funded by NSF and FDOT, and involves two industry partners: ISS and Econolite.

3 - Distributed Feedback Control of Traffic Flow Over Networks

Ketan Savla, University of Southern California, Los Angeles, CA, 90089, United States, ksavla@usc.edu

We discuss distributed properties of optimal feedback control for traffic flow over networks. For freeway networks, we consider the Cell Transmission Model, and identify sufficient conditions on network parameters and performance metrics under which the optimal control actions (variable speed limit, ramp metering, routing) are spatially distributed. We also provide adaptations of well-known distributed scheduling algorithms from stochastic networks that are maximally stabilizing for signalized arterial networks under interrupted traffic flow model.

4 - Data-Driven Digital Twin to Test Connected Infrastructure Environmental Applications: A Case Study of North Avenue Smart Corridor

Michael Hunter, Professor, Georgia Institute of Technology, Atlanta, GA, 30332-0355, United States, Angshuman Guin, Abhilasha Saroj, Somdut Roy, Randall Guensler

Leveraging real-time information and communication technologies the Atlanta Smart City North Avenue Smart Corridor data-driven digital twin provides a platform to test connected infrastructure environmental applications. A dynamic optimized connection between the real-time data and the simulation network objects is established using the simulation model's COM interface and python's Flask web framework. This interface is capable of injecting real-time signal phase, volume, and turn movement percentage data into the simulated network. The digital twin may be used to evaluate and visualize network performance indices, providing dynamic operational feedback in a real world environment.

5 - Coordinated Traffic Control Across Multiple Intersections: An Integer Programming Formulation and Lagrangian Decomposition with Subproblem Approximation

Pengfei (Taylor) Li, Assistant Professor, University of Texas Arlington, Arlington, TX, 39759, United States

A multi-intersection traffic control model is presented for safe vehicle movements across tightly connected intersections. All the intersections are viewed as one "super intersection" within which vehicles move according to their given paths. A Mixed integer linear programming formulation is presented for joint optimization of vehicle trajectories and traffic control. A scalable optimization frame for real-world traffic control optimization is designed, namely "Lagrangian decomposition with subproblem approximation" in which the dynamic network loading based lower bound estimator is constructed to relax constraints. Two examples are presented.

■ TD06

CC- Room 209

Analytics for Good

Sponsored: Data Mining

Sponsored Session

Chair: Joseph Cazier, Ph.D, Appalachian State University, Boone, NC, United States

Co-Chair: Ryan C LaBrie, Seattle Pacific University, Seattle, WA, 98119-1950, United States

Co-Chair: Gerhard Steinke, Ph.D, Seattle Pacific University, Seattle, WA, United States

1 - Evaluating AI Algorithms for Good with Ethical Audits

Ryan C. LaBrie, Ph.D, Seattle Pacific University, Seattle, WA, United States, ryanl@spu.edu, Gerhard H. Steinke

In recent years there has been much talk about the advancements in artificial intelligence (AI). AI technologies, and the ways we use them, are having positive as well as negative impacts on the world. We examine various visions of the future, from where analytics is used as a force for freedom, self-actualization, development and potential maximization, to where analytics is used as a tool of suppression, manipulation and exploitation. We investigate the premise that AI algorithms have flaws and may be biased. We suggest that AI algorithms go through an ethical algorithm audit and discuss a framework in which to institute these audits in order to not only "do no harm" but ideally produce "good for all".

2 - Juried Evidence: How an Automatic Evidentiary Rating System Can Lead to Better Decision Making and Help Build a Better Society

Edgar Hassler, Assistant Professor, Appalachian State University, Boone, NC, United States, hassleree@appstate.edu

Not all evidence is created equal. Common types of evidence include peer reviewed journal articles, expert opinion, observational evidence and data distilled from sensors. Many times this evidence can be contradictory or only apply in certain circumstances. Aggregating all of this evidence in one place and grading it for different situations can help decision makers make better decisions by harmonizing the evidence. This has many benefits for society as we can use the best knowledge we have to make better decision for health, business, policies and the environment. This presentation focuses on what such a system might look like and how it can be part of using analytics for good to build a better society.

3 - A Better Society Through Better Decisions - How Blockchain Technology Can Help to Make the Right Choices

Joseph Cazier, Center for Analytics Research and Education, Boone, NC, United States, cazierja@appstate.edu, Max A. Rünzel

Our values and convictions guide our actions. When it comes to purchasing decisions, we are willing to spend considerable price premiums if a product reflects what we stand and strive for. But how can we verify that our purchase decisions are in line with our values and norms? Distributed ledger technology as the blockchain offers the opportunity to document the origin and trace the pathway of products, and services in an intrinsically verifiable manner. This presentation develops conceptually how blockchain-enabled analytics can help to build a society that is more congruent with its values by facilitating decision making driven by transparency, integrity and accountability.

4 - Life Coach: Using Big Data and Analytics to Facilitate the Attainment of Life Goals

Joseph A. Cazier, Executive Director, Professor, Appalachian State University, Boone, NC, 28607, United States, cazierja@appstate.edu

Most of Big Data and Analytics work is focused on getting people to do what other people want them to do. What if it could be turned it around? What if all the data collected on or about individuals could instead be used to help individuals in ways they want to be helped? What if the data could help individuals achieve their life goals and dreams, and coach them through the process of life? If these individuals benefited from such a service and begin living happier, balanced, and fulfilled lives they will also become more beneficial employees to organizations.

■ TD07

CC- Room 210

Service Operations Analytics

Sponsored: Data Mining

Sponsored Session

Chair: Subodha Kumar

1 - The Effects of Social Media Content Created by Human Brands on Engagement

Rakesh Reddy Mallipeddi, Tulane University, Mays Business School, Dept of Info. & Operations, New Orleans, LA, 77843-4217, United States, Subodha Kumar, Ramkumar Janakiraman

In this study, we propose an econometric model to examine the drivers of human brand's social media engagement. Set in the context of national elections, we examine the effects of the tone of content created by human brands. To meet our objectives, we assemble a novel candidate-level data of social media engagement.

2 - Effect of Health Information Exchange Usage on Lab Test Orders

Aditya Jain, Baruch College, Zicklin School of Business, New York, NY, 10010, United States, aditya.jain@baruch.cuny.edu, Emre M. Demirezen, Subodha Kumar

We investigate how a physician use of HIE (Health Information Exchange) affects her test ordering behavior. We should this effect is negative and is moderated by patient's history of care and her clinical condition.

3 - The Behavioral Consequences of Shipping Policy Changes

Vamsi K. Kanuri, University of Notre Dame, Notre Dame, IN, 46556, United States, vkanuri@nd.edu, Andrew Crecelius, Subodha Kumar

Shifting consumer preferences are forcing retailers to leverage the value of multichannel behavior. Yet actionable evidence of strategies to inculcate multichannel behavior across the retailer's existing channels is lacking. This research addresses this gap by investigating the behavioral effects of an online shipping policy change at a large US retailer. Counterintuitively, we find that a generous shipping policy change shifts customers away from the online channel towards the offline, with a net positive effect on overall sales. The authors explain these findings through additional analyses and conclude with timely implications for multichannel management.

4 - The Impact of Brand Mentions in News Headlines on Social Media Engagement

Debashish Ghose, Temple University, Philadelphia, PA, 19144, United States, dghose@temple.edu, Subodha Kumar, Susan Mudambi

News publishers strive to create consumer buzz around their stories and generate web traffic on social media. To increase engagement, publishers create catchy headlines that often mention known brands. We empirically quantify the impact of human and product brand mentions on engagement. Our results indicate human brand mentions have a positive effect on retweets and this positive impact is greater for satirical news than for traditional news. Results implying the great potential of satirical political news vis-à-vis traditional political news help publishers better understand retweet behavior on social media.

5 - Tell Me What I Want: A Study of Assortment Planning for Learning Consumers

Yulia Vorotyntseva, Temple University, Philadelphia, PA, 19102, United States, yulia.v@temple.edu, Canan Ulu, Dorothee Honhon

We develop a model that incorporates consumer learning into a firm's assortment problem. Consumer's prior beliefs affects their choice of a product from a given category, and the subsequent experience, in turn, affects their beliefs and future choices. We analyze the firm's optimal assortment policy in this setting.

■ TD08

CC- Room 211

Artificial Intelligence for Cybersecurity

Sponsored: Artificial Intelligence

Sponsored Session

Chair: Tung Cu, Bloomsburg University of Pennsylvania, Bloomsburg, PA, 17815, United States

1 - Artificial Intelligence for Cybersecurity

Tung Cu, Northeastern Illinois University, Chicago, IL, 17815, United States

The next generation of Artificial Intelligence (AI) and Machine Learning (ML) are increasingly incorporated in cybersecurity solutions. Experts predict that, over time, companies will incorporate AI into every cybersecurity product portfolio. While AI and ML increase the defenders' capability to detect and prevent abnormal behavior patterns, attackers are also using AI and ML to learn about a target's vulnerabilities and launch attacks. In this study, we solicit high-quality original research papers, both theoretical and empirical, that address the issues of AI aid, misuse and threat in cybersecurity in different contexts such as business, healthcare, education, politics, and economics.

2 - Exploring Deviant Hacker Networks on Social Media Platforms

Nitin Agarwal, University of Arkansas-Little Rock, Little Rock, AR, 72204, United States, nxagarwal@ualr.edu, Samer Al-khateeb

The initial use of social media for benign purposes has now transitioned to include malicious activities. These nefarious uses of social networks pose a significant threat to society, and thus requires research attention. In this work, we study activities of hacker groups on social media, which we term Deviant Hacker Networks (DHNs). We investigated the connection between different DHNs on Twitter. In our work, we also attempted to bridge the gap between the empirical study of social networks, machine learning, and cyber forensics, as the growth of OSNs is now bringing these domains together, due to OSNs continuously generating vast amounts of evidentiary data.

3 - Leveraging Virtual, Augmented and Mixed Reality to Facilitate Intelligence

Michael W. David, Professor, National Intelligence University, Bethesda, MD, 20301, United States, Michael.David2@dodiis.mil, Margarita Baez

The Internet of Things and the imminence of wide 5G deployment in the public arena points to an avalanche of data that will leave businesses struggling to finds ways to address the profusion of new content created every year. Machine learning and artificial intelligence—on their own or in combination—have emerged as methods to control this tide, but where does this leave the cyber intelligence analyst? This research explores the possible applications of Virtual Reality, Augmented Reality, and Mixed Reality technologies to assist the Digital Network Analyst's ability to produce digital network intelligence. The goal is to help manage the high volumes and velocity of data available to the analyst.

4 - Security, Privacy, and Ethical Concerns on Human Radio-frequency Identification (RFID) Implants

Zhanel D. Tucker, Hampton University, Hampton, VA, 23669, United States, zhanel.tucker@gmail.com, Chutima Boonthum-Denecke

This report discusses the security, privacy, and ethical concerns on human RFID-implants. Emerging technologies are being developed to help with convenience for everyday people, but these conveniences can pose security and privacy threats. The uses of technology being implanted in humans without the proper assessment could cause a new wave of security flaws. This study will review how human RFID microchip implants will impact and effect security, privacy, and ethical concerns associated with the new initiative for RFID implants to be used on human beings.

5 - Patterns of Conflict in Human Computer Teaming

Amy Magnus, Research Assistant Professor, Air Force Institute of Technology, Wright-Patterson AFB, OH, 45387, United States, Amy.Magnus@afit.edu

Narrative analysis reveals patterns of work over the arc of a document. These patterns unearth the ways we engage a topic. We generalize by extracting workflows from documents then synthesize and transfer amended flows to addition topics. When we examine the corpi of teams, patterns of conflict emerge. Some conflicts are easy to resolve. Others prove difficult and contribute to insider threats. Computation can simultaneously frustrate and facilitate agency among team players. Thus computation contributes to team discord. To address sources of conflict, we consider the role of artificial intelligence in system regulation and examine its potential in managing the expectations of team membership.

6 - Time Anomaly Detection with AI

Tudor Morosan, AVP Data Science, NASDAQ, Residence, Boston, MA, M2J2K5, United States, tudor.morosan@yahoo.com

This abstract is introducing an anomaly detector capable to identify subtle deviation from normal in time series, using recurrent neural networks and auto-encoders.

■ TD09

CC- Room 212

Network Analytics and Predictive Models

Sponsored: Artificial Intelligence

Sponsored Session

Chair: John Rios, University of Iowa, Iowa City, IA, 52242, United States

1 - Predicting Stock Price Movements via Multi-relational Inter-firm Networks

John Rios, University of Iowa, Tippie College of Business, Iowa City, IA, 52242, United States, john-riosrodriguez@uiowa.edu, Kang Zhao, Nick Street

Predicting stock movements is challenging, but has attracted tremendous amount of attention from both practitioners and researchers. Meanwhile, firms are connected with each other in a multi-relational network and these diverse connections could provide helpful signals for the prediction of a firm's performance. Using real-world supply and competition networks among almost three thousand firms, this research predicts a firm's stock movements by leveraging performance of different types of network peers of a focal firm. We show that graph predictive models and features based on a firm's peers can improve the prediction of the firm's future stock price movements.

2 - Data-driven Sales Forecasting with Heterogeneous Promotion Effects

Stefan Feuerriegel, ETH Zürich, Weinbergstr., Zürich, 8092, Switzerland, sfeuerriegel@ethz.ch, Christopher Stoll, Klaus Möller

This paper studies a data-driven model for sales forecasting that is explicitly designed so that it estimates causal effects of promotions on sales. Formally, we adapt generalized random forests to this research setting: responses to treatments (i.e., promotions) are modeled conditional on covariates that characterize the between-store heterogeneity in order to infer conditional average treatment effects. We demonstrate our approach to causal sales forecasting based on 844,391 sales records from 292 stores. Our findings characterize the nature of the treatment effect across stores in foresight, thereby supporting future decision-making.

3 - Virtual Item Recommender Engine: A Heterogeneous Network Embedding Perspective

Vidit Mehta, University of Maryland, College Park, College Park, MD, United States, vidit@rhsmith.umd.edu, Kunpeng Zhang

Recommender systems are a core tool for businesses to showcase their products and services. We make the observation that many a time, consumers simultaneously interact with businesses, product categories and products (for instance during Thanksgiving sales). We can think about such dynamic interactions as a part of a huge network with multiple types of nodes. We propose a novel network-embedding model for making recommendations to users in social networks. We find that our proposed model consistently outperforms other state-of-the-art recommender systems, thereby highlighting the importance of making recommendations based on meaningful relationships amongst various nodes in network space.

4 - Course Recommendation Based on Collaborative Filtering

Camilo Franco, Universidad de los Andes, Bogotá, Colombia, c.franco31@uniandes.edu.co, Nicolás Hernández, Haydemar Nuñez, Felipe Montes

Recommender systems are a popular tool that can be used to identify relevant items for interested users. Examining collaborative filtering as a basic social recommender system, as it builds recommendations from similar user rating behavior, it allows making use of other sources of information that may enhance its performance by accomplishing sparse models with higher degrees of accuracy. This proposal addresses social collaborative filtering for course recommendation, exploring a hybrid/social recommendation systems approach to academical communities for aiding students in the planning of their curriculum and the consequent enrollment in courses.

5 - Ebook Adoption Behaviors Through an Online Sharing Platform: A Multirelational Network Perspective

Xi Wang, Central University of Finance and Economics, School of Information, Central University of Finance and Economics, Beijing, 100080, China, xiwang@cufe.edu.cn

The aim of this study was to construct a multi-relational network for an online sharing platform in the age of the sharing economy, to identify the factors impacting users' product adoption behavior, and to predict consumers' purchases of user-generated products on the platform. We conducted multi-relational network analyses of 5 different sub-networks in identifying influential factors for E-book adoption. Meanwhile, the study adopted machine learning methods with different classification algorithms and feature sets to predict users' purchasing behaviors.

■ TD10

CC- Room 213

Joint Session SMA/Practice Curated: Word of Mouth and Online Customer Review Analytics

Sponsored: Social Media Analytics

Sponsored Session

Chair: Ali Hojjat, University of New Hampshire, Durham, NH, 03824, United States

1 - How Should Incumbent React to Disruption? A Hybrid Analytics Approach Leveraging Machine Learning and Quasi-experiments

Wei Chen, University of Arizona, Tucson, AZ, 85718, United States, weichen@email.arizona.edu, Karen Xie, Jianwei Liu, Yong Liu

The disruption of sharing economy to incumbent organizations is clear. However, the literature is silent on whether incumbent organizations should react to the sharing economy disruption, and if so, how. In this research, we fill the void by tracing the quality change of hotels after the entry of home sharing and identifying quality improvement opportunities taken notes by hotel managers in online reviews that explain the change. Our hybrid methods combine casual inference and machine learning and add new perspectives to the emerging literature on sharing economy.

2 - Impact of Social Media Recommendations on Media Performance

Sameer Borwankar, Purdue University, West Lafayette, IN, 47906, United States, sborwank@purdue.edu

This talk focuses on how the recommendations shared on social media influence the media (movies, song, etc) performance.

3 - Toward a Better Online Platform Review: Should Customers be Compensated for Providing Reviews?

Peng LI, Rutgers Business School, Highland Park, NJ, 08904, United States, Soohyun Cho, Arim Park, Yao Zhao

In recent years, online review platforms have emerged as indispensable research and business tools for consumers and businesses alike. To amplify their business profiles on online review platforms, some small businesses have begun compensating customers for platform reviews. In this paper, we seek to learn how compensated reviews affect customers, (small) businesses, and online review platforms.

4 - Detecting Anomalous Online Reviewers: A Novel Hierarchical Machine Learning Approach

Naveen Kumar, University of Washington, Bothell, WA, 98012, United States, Deepak Venugopal, Liangfei Qiu, Subodha Kumar

Online reviews and discussions play a significant role in influencing decisions made by users in day-to-day life. However, the presence of reviewers who deliberately post fake or deceptive reviews for financial or other gains negatively impacts both users and businesses. Unfortunately, automatically detecting such reviewers is well known to be a challenging problem, particularly since fake reviews do not seem out-of-context as compared to genuine reviews. In this paper, we propose a novel machine learning approach for this task. Our approach is highly generalizable, allows us to seamlessly combine both univariate and multivariate distributions into a unified anomaly detection system.

5 - Using Text Modeling and Latent Dirichlet Allocation to Study Customer Complaints

Shih-Hsien Tseng, Chung Yuan Christian University, Taoyuan City, Taiwan

Many organizations collect complaint information using Twitter. Clustering such complaints can help with prioritizing issues and diagnosing the problems. We show innovative visualizations and analysis methods to transform clustering outputs into useful improvement insights. Real data from a Taiwanese company illustrates the approaches.

■ TD11

CC- Room 214

Stochastic Systems

Sponsored: Applied Probability

Sponsored Session

Chair: Mark S. Squillante, IBM Thomas J. Watson Research Center, Yorktown Heights, NY, 10598, United States

1 - Confidence Regions in Wasserstein Distributionally Robust Estimators

Nian Si, Stanford University, Stanford, CA, United States, Jose Blanchet, Karthyek Murthy

Wasserstein distributionally robust optimization (DRO) estimators are obtained as the solution of a min-max problem in which the statistician selects a parameter minimizing the worst-case loss among all probability models within a certain distance from the underlying empirical measure. In addition to producing estimators endowed with enhanced robustness properties, Wasserstein DRO estimators recover as a particular case a wide range of regularized estimators, including LASSO and support vector machines. This paper studies the asymptotic normality of underlying DRO estimators as well as the properties of an optimal confidence region induced by the Wasserstein DRO formulation.

2 - Extremal Queues with Given Mean Absolute Deviation

Johan van Leeuwaarden, TU Eindhoven and Tilburg University, Eindhoven, Netherlands, Dick den Hertog

A notorious problem in queueing theory is to identify the worst possible performance of the GI/G/1 queue under mean-dispersion constraints for the interarrival and service time distributions. We address this extremal queue problem by measuring dispersion in terms of Mean Absolute Deviation instead of variance and using Distributionally Robust Optimization. We obtain the extremal interarrival time and service time distributions, and hence the sharpest possible bounds, on all moments of the waiting time.

3 - Subexponential Rate of Convergence of a Class of Levy-driven Stochastic Differential Equations for Parallel Server Networks

Guodong Pang, Penn State University, Industrial and Manufacturing Engineering, University Park, PA, 16802, United States, Ari Arapostathis, Nikola Sandric, Hassan Hmedi

We study the ergodic properties of a class of controlled Levy-driven SDEs. They include the scaling limits arising from parallel-server networks in the Halfin-Whitt regime. We identify conditions on the parameters in the drift, the Levy measure and/or covariance function which result in (uniform) subexponential and/or exponential ergodicity. For the stochastic network models, we show that the rate of convergence is polynomial and provide a sharp quantitative characterization of the rate via matching upper and lower bounds.

4 - Optimal Control of Fluid Models of Switched Networks

Mark S. Squillante, IBM Thomas J. Watson Research Center, Yorktown Heights, NY, 10598, United States, mss@us.ibm.com, Yingdong Lu, Tonghoon Suk

We consider issues related to optimal scheduling in fluid models of input-queued switches, the latter being widely used in modern computer and communication networks. We derive the corresponding optimal control policy and establish structural properties for the optimal solution.

■ TD12

CC- Room 2A

Applied Probability and Statistical Learning

Sponsored: Applied Probability

Sponsored Session

Chair: Zeyu Zheng, University of California-Berkeley, Berkeley, CA, 94720, United States

1 - A Finite Time Analysis of Temporal Difference Learning

Jalaj Bhandari, Columbia University, New York, NY, United States, Daniel Russo

Temporal difference learning (TD) is a simple iterative algorithm used to estimate the value function corresponding to a given policy in a Markov decision process. Although TD is one of the most widely used algorithms in reinforcement learning, its theoretical analysis has proved challenging and few guarantees on its statistical efficiency are available. In this work, we provide a simple and explicit finite time analysis of temporal difference learning with linear function approximation. Except for a few key insights, our analysis mirrors standard techniques for analyzing stochastic gradient descent algorithms, and therefore inherits the simplicity and elegance of that literature.

2 - On Efficient Optimal Transport: An Analysis of Greedy and Accelerated Mirror Descent Algorithms

Tianyi Lin, University of California, Berkeley, Berkeley, CA, 94706, United States, Nhat Ho, Michael Jordan

We provide theoretical analyses for two algorithms that solve the regularized optimal transport (OT) between two discrete probability measures with at most n atoms. We show that a greedy variant of the Sinkhorn algorithm can be improved to O(n^2/eps^2), outperforming the best known complexity bound of O(n^2/eps^3). This matches the best known complexity bound for the Sinkhorn algorithm and explains why the Greenkhorn algorithm outperforms the Sinkhorn algorithm in practice. We also develop a class of algorithms that we refer to as APDAMD algorithms with the solid guarantee. Experimental results on synthetic and real datasets demonstrate the favorable performance of our algorithms in practice.

3 - Adaptive Stratified Sampling with Infinite Stratums

Teng Zhang, Stanford University, Menlo Park, CA, 94025, United States, Jose Blanchet, Peter Glynn, Zeyu Zheng

Stratified sampling, serving as an important tool for variance reduction, gives rise naturally to an infinite number of stratums (sub-groups) in applications such as Multi-level Monte Carlo (MLMC). Moreover, the optimal allocation of sampling resources depends on stratum variance which is usually unknown a priori, such that adaptive online sampling schemes are in need. We analyze the problem of stratified sampling with infinitely many stratums and unknown optimal allocation. We show that the canonical $O(n^{-1/2})$ convergence rate can be achieved as well as the asymptotic optimal efficiency.

4 - Dynamic Pricing with Inventory Constraints and External Information

Zeyu Zheng, University of California, Berkeley, Berkeley, CA, 94720, United States, zyzheng@berkeley.edu, Xiaocheng Li

We consider scenarios when the price of a product is dynamically chosen by a decision maker to maximize the profit over many time periods. Specifically in this setting, external covariates information which can impact the product demand are available and a limited overall inventory can be imposed. We first provide a new online learning algorithm to achieve a square root T upper bound, and then develop new tools to establish lower bound on the same order.

■ TD13

CC- Room 2B

APS-MSOM Service SIG: Special Invited Lecture on Ride-Hailing Two-Sided Marketplace

Sponsored: Applied Probability

Sponsored Session

Chair: Jing Dong, Columbia University, New York, NY, 60208, United States

Co-Chair: Jamol Pender, Cornell University, Ithaca, NY, 14850, United States

1 - Ride-hailing Technologies, Powered by Mapping

Dawn Woodard, Director of Data Science, Maps, Uber, School of OR & IE, San Francisco, CA, 14850, United States

Extensive literature exists on methods for pricing and matching in ride-hailing platforms (such as Uber and Lyft), but less attention has been paid to the mapping inputs required. For example, carpool matching requires predictions of travel time between any two locations in the road network. We survey such methods for mapping. First, we show how one can perform robust decision-making by measuring and accounting for uncertainty in the travel time predictions. Next, we propose a machine learning architecture for travel time prediction that captures the detailed dynamics of traffic patterns in a road network. Finally, we discuss how to handle uncertainty, and fix errors, in the road network data itself.

■ TD14

CC- Room 302

Information Design in Revenue Management

Sponsored: Manufacturing & Service Oper Mgmt

Sponsored Session

Chair: Shouqiang Wang, The University of Texas at Dallas, Richardson, TX, 75080, United States

Co-Chair: Can Kucukgul, 1989, Richardson, TX, 75080, United States

1 - Bayesian Persuasion with Communication

Kimon Drakopoulos, University of Southern California, 2928 West 78th Place, Los Angeles, CA, 90305, United States

In this paper we consider the problem of Information Design where agents can exchange information about the received signals. In particular we consider a firm that is ex-post informed about the quality of a product and customers who are deciding on their purchasing decisions. Customers, upon receiving signal from the firm regarding the unknown quality of the product exchange their information with probability p. We show that the optimal signaling mechanisms have very different structure for different values of p underlining that communication an important disadvantage of private signaling mechanisms.

2 - Persuasion in Online Retail: Efficacy of Public Signals

Krishnamurthy Iyer, University of Minnesota, Minneapolis, MN, 14850, United States, kriyer@umn.edu, David Lingenbrink

We study an online retail setting, where strategic customers seek to purchase an item with a finite inventory in one of two time periods. Only the firm knows the inventory and demand, and seeks to persuade strategic customers to buy in the first time period, when the price is higher. We analyze both public and private persuasion mechanisms, and find that, with homogeneous customers, it is optimal to signal publicly: the firm cannot raise its revenue by sending different private signals to different customers. When customers are heterogeneous, we numerically investigate the performance of various public and private persuasion mechanisms.

3 - Persuasion in Networks: Large Networks

Ozan Candogan, University of Chicago, Booth School of Business, Chicago, IL, 27708, United States, ozan.candogan@chicagobooth.edu

Agents in a social network take binary actions that exhibit local strategic complementarities. Agents are a priori uninformed about a payoff-relevant state. An information designer chooses a public signaling mechanism that sends an informative signal about the underlying state to maximize the total number of agents who take action 1. We investigate how to design mechanisms when only partial information about the network structure is available. We show that using only the degree distribution and an asymptotic characterization of cores in large random networks, it is possible to construct asymptotically optimal signaling mechanisms.

4 - Engineering Social Learning: Information Design of Time Locked Sales Campaigns for Online Platforms

Can Kucukgul, The University of Texas at Dallas, Richardson, TX, 75080, United States, cxk151030@utdallas.edu, Ozalp Ozer, Shouqiang Wang

Many online retailing platforms nowadays offer time-locked sales campaigns as an innovative selling mechanism, whereby third-party sellers sell their products at a typically discounted price for a fixed time horizon of pre-specified length. To incentivize purchases, platforms provide some information on up-to-date sales as campaigns progress, in the hope of influencing an upcoming consumer's valuation of products. We propose an easy-to-implement and near optimal information provision strategy for such a time-locked sales campaign. Our policy has important managerial implications, and yields significant profit improvement upon some naïve policies currently implemented in practice.

■ TD15

CC- Room 303

NSF

Emerging Topic: NSF

Emerging Topic Session

Chair: Jeff Cohen, INFORMS, Catonsville, MD, 21228, United States, jeff.cohen@informs.org

Chair: Sheldon H. Jacobson, University of Illinois, Dept of Computer Science, Urbana, IL, 61801-2302, United States

1 - The National Science Foundation (NSF)

Jeryl L. Mumpower, NSF, Alexandria, VA, United States

The National Science Foundation (NSF) offers a number of funding opportunities for INFORMS investigators, not only within disciplinary programs in Engineering and Foundation-wide, cross-cutting initiatives, but also within the Directorate for Social, Behavioral, and Economic Sciences. This presentation will describe opportunities that are relevant to INFORMS communities, with particular emphasis on Decision, Risk, and Management Science program in the Division of Social and Economic Sciences. DRMS was established in 1982 and was the first program at NSF to specifically embrace INFORMS research. This talk will briefly discuss the history of the DRMS program and its relation to programs in Engineering that support research by members of the INFORMS research communities. The talk will also briefly describe guidelines for proposal preparation and NSF's Intellectual Merit and Broader Impacts criteria. Question-and-answer session will follow the presentation.

■ TD16

CC- Room 304

Machine Learning for Online Platforms

Sponsored: Manufacturing & Service Oper. Mgmt/Service Operations

Sponsored Session

Chair: Negin Golrezaei, Google Inc., Cambridge, MA, 02142, United States

Co-Chair: Adel Javanmard, University of Southern California, Los Angeles, CA, 90089, United States

1 - Dynamic Incentive-aware Learning: Robust Pricing in Contextual Auctions

Adel Javanmard, University of Southern California, Los Angeles, CA, 90089, United States, Negin Golrezaei, Vahab Mirrokni

We consider the problem of robust learning of reserve prices against strategic buyers, in repeated contextual second-price auctions. Buyers' valuations for an item depend on the context that describes the item. However, the seller a priori is not aware of the relationship between the context and buyers' valuations. The seller's goal is to design a learning policy to set reserve prices using the past sales data, and her objective is to maximize her total revenue. On the other side, utility-maximizing buyers have the incentive to bid untruthfully to manipulate the seller's learning policy. We propose learning policies that are robust to strategic buyers and quantify their performance analytically.

2 - Dynamic Learning in the Stochastic Assignment Problem

Assaf Zeevi, Columbia University, New York, NY, 10027, United States

We consider a sequential stochastic assignment problem that involves objects of random "quality" that need to be "assigned correctly" to generate maximal rewards. The original version of the problem was first introduced close to 50 years ago, and considered the assignment of workers to tasks. It has since served as an important modeling paradigm for various other OR/MS problems, though in all this line of literature, the underlying stochastic model is assumed to be known a priori. In this talk we relax this assumption and propose online learning algorithms that estimate this on the fly while concurrently optimizing the assignment objective.

3 - Contextual Pricing via Intrinsic Volumes

Jon Schneider, Google Research, New York, NY, 10018, United States

We present a new algorithm for the dynamic pricing problem (which can be realized as a special case of the contextual search problem) that achieves Od(loglogT) total loss, improving on the previous best known upper bounds of Od(logT) and matching the known lower bounds (up to a polynomial dependence on d). To do this, we introduce the problem of contextual search, a multidimensional generalization of binary search that captures many problems in contextual decision-making. Both algorithms make significant use of ideas from the field of integral geometry, most notably the notion of intrinsic volumes of a convex set.

4 - Learning from the Crowd

Nika Haghtalab, Cornell University, Ithaca, NY, 15213, United States

Crowdsourcing has become the method of choice for gathering labeled training data for learning algorithms. Standard approaches to crowdsourcing view the process of acquiring labeled data separately from the process of learning a classifier from that data. This can give rise to computational and statistical challenges —- as in most cases there are no computationally efficient learning algorithms that tolerates the high levels of noise in crowdsourced datasets, and efforts to eliminate noise through voting require a large number of queries. We show how by interleaving the process of labeling and learning, we can attain computational efficiency with much less overhead in the labeling cost.

■ TD17

CC- Room 305

Special Topics in Revenue Management

Sponsored: Manufacturing & Service Oper. Mgmt/Service Operations

Sponsored Session

Chair: Gustavo J. Vulcano, Universidad Torcuato di Tella, Buenos Aires, 1428, Argentina

Co-Chair: Victor Araman

1 - Dynamic Analysis of Real-time Nonlinear Pricing for Services Offered To The Strategic Customers in A Heterogeneous Market

Roozbeh Yousefi, Queen's University, Kingston, ON, K7K7M3, Canada, r.yousefi@queensu.ca, Jue Wang, Yuri Levin, Mikhail Nediak

We study optimal dynamic pricing for services offered to heterogeneous customers with different strategic behavior, under either unlimited usage subscriptions or per-usage purchase. We modeled a discrete choice problem for the customers in a dynamic market in aggregate level and used that to formulate the firm's profit maximization in terms of optimal control. We derived the optimality conditions and investigated the turnpike property of the solution, studied the dynamic aspects, optimize the length of the contract and demonstrate how subscription helps firm to exploit strategic behavior.

2 - Pricing in a Mixed Logit Demand Model with Network Effects

William L. Cooper, University of Minnesota, Minneapolis, MN, United States, Fatemeh Nosrat, Zizhuo Wang

A product displays network effects if each individual customer's valuation for the product increases in its overall sales. In this talk, we consider a pricing problem for a product that exhibits network effects. The primary objective in the pricing problem is to find a revenue-maximizing price for the seller of the product. We will focus on a setting in which demand and sales are built on a variation of the mixed multinomial logit (MMNL) choice model. We will discuss approaches for solving the seller's price optimization problem, and discuss insights from a numerical study.

3 - Two-stage Assortment Optimization with Recommendation

Venus Lo, Cornell University, Ithaca, NY, United States, vhl8@cornell.edu, Huseyin Topaloglu

In the first stage, a customer arrives and has an initial product which she wishes to buy, following the independent demand model. If her desired product is in the assortment, she purchases it and leaves. Otherwise, we move onto the second stage, where the customer's type is revealed based on the initial product. Her type reveals her preferences for the products. The retailer recommends a subset of his assortment based on her type, and she either chooses a product in the recommended subset according to MNL, or leaves without a purchase. The assortment optimization problem is NP-hard. We present a FPTAS when the number of customer types, is fixed, and present an inapproximability result.

4 - Supply Positioning for Marketplace Balance at Lyft

David Crapis, Lyft Inc., Berkeley, CA, 94709, United States

Lyft supply positioning system powers a suite of products that allow Lyft drivers to reposition themselves where they are most needed. Our system selects a combination of demand signals and monetary incentives with the goal of improving service levels and ultimately increase earnings for drivers. At the core of the system there is an optimization algorithm that relies on demand and supply forecasts. We will discuss the key aspects of the supply positioning problem and we will describe some of the challenges in solving this problem in the real world.

■ TD18

CC- Room 306

Supply Chain Management

Sponsored: Manufacturing & Service Oper. Mgmt/Supply Chain

Sponsored Session

Chair: C Gizem Korpeoglu, University College London, London, WC1E 6BT, United Kingdom

1 - Demand Pooling in Omnichannel Operations

Xiaolin Xu, Nanjing University, School of Business, Nanjing, 210093, China, xuxl@nju.edu.cn, Ming Hu, Weili Xue, Yi Yang

Many traditional retailers and e-tailers like Walmart and Amazon have been implementing omnichannel strategies, such as buy-online pickup-at-store (BOPS), buy-online ship-to-store (BOSS), and buy-online ship-from-store (BOFS). We build a stylized model to investigate the impacts of these omnichannel strategies on store operations from an inventory perspective.

2 - Improving Yield of Small Holder Farmers: Welfare Analysis

Utku Serhatli, INSEAD, Constance de le Boulevard, Fontainebleau, 77590, France, utku.serhatli@insead.edu, Guillaume Roels

To help secure supply in agricultural-intensive economies, manufacturers often help smallholder farmers improve their yields through training and certification programs. However, and perhaps paradoxically, some farmers feel that these programs can decrease commodity prices, which in turn can affect their profits negatively. We formulate this problem as a Stackelberg game where in the first stage, the manufacturer decides which farmers to help, and in the second stage, farmers engage in a Cournot competition in the face of yield uncertainty. We investigate the implications of such practices on the manufacturer's and farmers' profits, considering both total welfare and social inequality.

3 - A Two-Sided Budget Neutral Incentive Program for Coordinating an Influenza Vaccine Supply Chain with Endogenous Supply and Demand under Uncertainty

Kenan Arifoglu, UCL, London, United Kingdom, k.arifoglu@ucl.ac.uk, Christopher S. Tang

This paper considers a decentralized flu vaccine supply chain consisting of rational individuals and a profit-maximizing manufacturer with uncertain yield. We develop a two-sided incentive program to counteract 'demand-side inefficiency' caused by individuals' rational behavior and 'supply-side inefficiency' caused by the manufacturer's uncertain yield, and thereby coordinate the flu vaccine supply chain. On the demand side, we propose tax/subsidy payments between the social planner and vaccinated individuals, that depend on the realized yield. On the supply side,we propose a transfer payment between the social planner and manufacturer, which is also contingent on the realized yield.

4 - Reshoring or Offshoring? Impacts of Markets, Tariffs, and Premiums of Domestic Manufacturing

Xin Wang, Hong Kong University of Science and Technology, Kowloon, Hong Kong, xinwang@ust.hk, Kanglin Chen, Ying-Ju Chen, Baozhuang Niu

We analyze the reshoring decision of a global manufacturer that is based in a developed country and sells its product in both domestic and overseas markets. The manufacturer can offshore productions overseas to serve both markets, or reshore production back to the developed country and serves two markets separately. We find that when the domestic market size is large, reshoring might not be optimal. In addition, raising tariffs might cause less reshoring. Finally, reshoring may hurt consumers surplus even though consumers value domestically manufactured goods more.

■ TD19

CC- Room 307

Coping with Uncertainties in Supply Chain

Sponsored: Manufacturing & Service Oper. Mgmt/Supply Chain

Sponsored Session

Chair: Jun Ru, Pomona, CA, 91768, United States

1 - Association Between Diversification Strategies and Inventory Performance

Zhuang Qian, Assistant Professor, Pennsylvania State University Scranton, Dunmore, PA, United States, zuq35@psu.edu, Charles X. Wang

We conduct an empirical study to examine the associations between the firm's diversification strategies and inventory performance. Based upon a large sample of U.S. publicly traded firms, we find that (1) firms that are more diversified into related product segments hold more inventory; (2) firms that are more diversified into unrelated product segments hold less inventory; and (3) firms that are more internationally diversified hold more inventory. Based upon our empirical results, we offer important insights on achieving the strategic fits between diversification strategies and inventory decisions.

2 - Component Procurement for an Assembly Supply Chain with Random Capacities and Random Demand

Xiang Fang, University of Wisconsin-Milwaukee, Milwaukee, WI, 53211, United States, fangx@uwm.edu, Xinyan Cao

We consider a decentralized assembly supply chain with n suppliers and an assembler. Each supplier faces an uncertain production capacity. We formulate the problem as a two-stage Stackelberg game. We analytically characterize the equilibrium of this game, based on which we obtain several managerial insights. Particularly, we show that a reduction in one supplier's production cost or capacity uncertainty, or an increase in the component salvage value, might sometimes hurt this particular supplier's profitability. Furthermore, we demonstrate that when the suppliers' capacities become more positively correlated, the assembler is always better off, but the suppliers might be better or worse off.

3 - Retailer- vs. Vendor-managed Inventory: Manufacturer Margin, Product Substitution, Consumers' Store Loyalty

Jun Ru, California State Polytechnic University, Pomona, College of Business Administration, Pomona, CA, 91768, United States, jru@cpp.edu

The extant literature that studies the impacts of vendor-managed inventory (VMI) on the supply chain focuses only on a single-product setting, but in practice a retailer carries multiple products that are partially substitutable and supplied from different vendors. Therefore, this paper considers a supply chain consisting of two manufacturers and one retailer. Each manufacturer supplies a product to the retailer and both products are partially substitutable. We aim to shed light on how VMI affects the performance of each supply chain member as opposed to retailer-managed inventory (RMI) in a two-product setting.

4 - Product Quality Strategy in the Presence of Consumer Heterogeneity of Technology Platform

Xiuli He, UNC-Charlotte, Sugar Land, TX, 77479, United States, Yong Zha, Subodha Kumar

We study a smartphone device manufacturer's quality and price decisions when consumers differ in their willingness to pay for device quality. We first study the case where the manufacturer faces an exogenous OS quality (no customization). We find that the optimal device quality is not monotonic in OS quality.

■ TD20

CC- Room 308

Teaching in a Business Analytics Program

Sponsored: Education

Sponsored Session

Chair: Vera Tilson, University of Rochester, Rochester, NY, 14627, United States

1 - Teaching Big Data to MS Business Analytics Students

David Tilson, University of Rochester, Simon Business School, Rochester, NY, 14627, United States

Please check the mobile app for this abstract.

2 - AWOL - The Analytics Concepts Missing in Our Courses

Srini Krishnamoorthy, Simon Fraser University, Vancouver, BC, Canada, srinivas_krishnamoorthy@sfu.ca

The talk will focus on incorporating the analytics concepts that we tend to exclude from our courses. We teach the normal distribution but ignore the power law distribution. We teach linear regression but ignore quantile regression. Often these neglected concepts are more useful for real world managers.

3 - A Series of In-class Activities Used to Teach an Introductory Course in Business Intelligence

Wendy Swenson Roth, Georgia State University, Atlanta, GA, 30302, United States

Variety in student backgrounds and long class sessions require modifications to the normal lecture delivery of materials. A series of short in-class activities have been developed to give students practice with various concepts discussed in class such as cleaning data, creating a decision tree and visualizations.

4 - A Collaborative Negotiation Process for Incorporating Writing in a Data Science Course

Dessislava Pachamanova, Professor, Babson College, 231 Forest St, Wellesley, MA, 02457, United States, dpachamanova@babson.edu, Kristen Getchell

Drawing on writing-across-the-curriculum and writing-in-the-disciplines scholarship, we illustrate how incorporating exploratory and discipline-specific written communication activities into an intensive graduate data science course can improve disciplinary outcomes.

■ TD21

CC- Room 309

Inventory Management Facing Financial and Risk Concerns

Sponsored: Manufacturing & Service Oper. Mgmt/iFORM

Sponsored Session

Chair: Rong Li

1 - Inventory Management under Corporate Income Tax

Yixuan Xiao, Washington State University, Pullman, WA, United States, Zhan Pang

Corporate income tax (CIT) is a major financial cost in most business operations and after-tax profit is one of the most important financial performance indicators of a firm. We incorporate CIT into inventory models to analyze how CIT impacts inventory decisions under both accrual accounting and cash accounting methods. We formulate the inventory control problem under CIT as a cyclic stochastic dynamic program with multiple accounting periods each of which consists of multiple ordering periods and characterize the structures of optimal policy under different accounting methods.

2 - Supply Contracting under Changing Conditions

Long Gao, School of Business, UC Riverside, Riverside, CA, United States, long.gao@ucr.edu

We study how changing supply conditions affect the optimal procurement contract under information asymmetry. We characterize the structure of the optimal contract, and refine several results from the static framework. Finally, we provide guidelines for managing long-term procurement under changing supply conditions.

3 - Market Frictions and Advance Payment Mechanisms in Pre-shipment Financing

Fasheng Xu, Washington University in St. Louis, Campus, Saint Louis, MO, 63130, United States, fasheng.xu@wustl.edu, Panos Kouvelis, Wenhui Zhao

Most of the innovation and initiatives around early payment, like different types of trade credit, revolve around post-shipment approved invoice financing. But, if waiting to get funded until the invoice was approved, many SME suppliers would have cash flow challenges and difficulty financing production activities upfront. To fill this gap, we study a pull-structure supply chain with a large retailer and a cash-constrained SME supplier who needs the bank financing from the bank.

4 - Inventory Management Facing Multiple Risk Behavior Biases

Rong Li, Syracuse University, Syracuse, NY, United States, rli138@syr.edu, Shuxiao Sun

The behavioral OM literature have demonstrated experimentally the existence of the newsvendor decision bias—-order too few of high-profit products and too many of low-profit products—-and explained theoretically by a single risk behavior bias. Since the risk behavior bias indeed arise from two dimensions: risk perception and risk propensity, this paper attempts to explain the decision bias theoretically by two biases: overprecision (a risk perception) and risk aversion (a risk propensity) which are commonly observed. Interestingly this paper finds that when a manager possesses a certain degree of both types of biases, he may behave as an unbiased decision-maker.

■ TD22

CC- Room 310

Energy Policy

Sponsored: Manufacturing & Service Oper. Mgmt/Sustainable Operations

Sponsored Session

Chair: Saed Alizamir, Yale University, New Haven, CT, 06520, United States

Co-Chair: Safak Yucel, Georgetown University, Washington, DC, 20057, United States

1 - Investment in Wind Energy: The Role of Subsidy Policies

Foad Iravani, University of Washington, Foster School of Business, ISOM Department, Seattle, WA, 98195-3226, United States, firavani@uw.edu

Wind energy investment in the U.S. has significantly increased over time. Because wind energy provides electricity without carbon emissions, the government has been promoting wind energy investment through subsidy programs. We analyze the role of generation subsidy and investment subsidy on potential investors and examine the effects of investor characteristics on the optimal subsidy mechanisms. We also study the benefits of implementing the subsidy programs regionally, as opposed to federal implementation.

2 - Demand Response in Wholesale Electricity Markets

Asligul Serasu Duran, Assistant Professor, University of Calgary, Calgary, AB, Canada, serasu.duran@haskayne.ucalgary.ca, Baris Ata, Ozge Islegen

We explore the participation and the compensation of demand response (DR) providers in wholesale electricity markets over the long term, motivated by the Federal Energy Regulatory Commission's order that authorized DR resources to receive the same market clearing prices that generating resources receive. We model the equilibria in wholesale energy and capacity markets under various scenarios of DR participation, and investigate the impact of different DR compensation and penalization policies.

3 - A Reduce-to-threshold Approach to Direct Load Control Contracts with Monthly Constraints

Ali Fattahi, Johns Hopkins University, Anderson School of Management, Baltimore, MD, 90095, United States, ali.fattahi@jhu.edu, Foad Iravani, Sriram Dasu, Reza Ahmadi

Demand response programs are among strategies that utilities use to reduce electricity consumption during peak hours. Direct Load Control Contracts are a class of incentive-based demand response programs that allow utilities to directly “call” consumers through remote control devices and reduce their usage. We formulate an optimization model for executing DLCCs that minimizes cost subject to monthly and annual constraints on the number of times and hours customers can be called. We develop a hierarchical approximation scheme that solves the problem effectively. Our experiments with real data from the California system operator show that our approximation scheme performs remarkably well.

4 - A Structural Analysis of Consumer Electricity Demand Response to Dynamic Pricing

Bhavani Shanker Uppari, Singapore Management University, Singapore, 178899, Singapore, bhavaniu@smu.edu.sg, Kashish Arora

A large proportion of world’s electricity demand is going to be met by renewable sources in the next decade. This poses a huge operational challenge: balancing the highly variable renewable electricity supply and the (relatively more) static demand. Using data from a large scale experiment in London, we examine the effect of dynamic prices (pushed through smart meters) on the response of consumers’ demand. We build a consumer-level structural model of pricing and electricity consumption. Using the resultant estimates, we evaluate the efficacy of various policies (e.g., different tariff schemes and capacity allocations across different power sources) in terms of matching supply with demand.

5 - Electricity Consumption for Rationally Inattentive Households

Michael R. Blair, Yale University, New Haven, CT, United States, michael.blair@yale.edu, Saed Alizamir, Shouqiang Wang

We examine the electricity consumption decision for households who are rationally inattentive in a dynamic setting. That is, households pay a cognitive cost for processing information about an underlying stochastic process. As a result, households update their information and consumption infrequently. We characterize the household’s optimal consumption and information processing decisions over an infinite horizon, and show that this policy involves periodic inspections. Furthermore, our preliminary empirical analysis validates our findings.

■ TD23

CC- Room 3A

Healthcare Decision Analysis

Sponsored: Decision Analysis

Sponsored Session

Chair: L. Robin Keller, University of California, Irvine, CA, 92697-3125, United States

Co-Chair: Cristina del Campo, University of California, Irvine, Universidad Complutense de Madrid, Irvine, CA, 28223, United States

1 - Challenges in Modelling Time Dependent Transitions in Cost-effectiveness Analysis

Jiaru Bai, Wake Forest University, Binghamton University, School of Management, Winston Salem, NC, 13902, United States, baij@wfu.edu, Cristina del Campo, L. Robin Keller

We propose challenges in estimating Markov model parameters with limited clinical data. With limited data from registration trials, we developed a way to estimate time-dependent transition probabilities in a Markov model for cancer progression. The method is applied to cervical cancer data in a clinical study.

2 - Enhancing understanding of Probability Updating with Bayes’ Rule

Alexander Robinson, University of California at Irvine, California, Irvine, CA, 92617, United States, arobins3@uci.edu, L. Robin Keller, Cristina del Campo

The process of calculating updated probabilities via Bayes’ theorem and interpreting them should be improved to avoid errors and enhance understanding. Updating probabilities given new evidence is a technique that has applications in a number of fields, in particular healthcare. Stating probabilities as numbers of people out of a total number will help health care providers, care givers and patients better understand and retain the information.

3 - A Two-Step Markov Processes Approach for Parameterization of Cancer State-Transition Models for Low- and Middle-Income Countries

Chaitra Gopalappa, University of Massachusetts Amherst, Belchertown, MA, United States, chaitrag@umass.edu, Guo Jiachen, Jeremy Lauer, Andre Ilbawi, Carel Pretorius

In low- and middle-income countries (LMICs), screening and early diagnosis programs are generally unavailable, and most cancers are diagnosed in late stages when survival is very low. As part of the Sustainable Development Goals, countries aim to reduce premature mortality from cancers and are in preparation of an ‘investment case’, economic analysis to identify prioritized interventions. However, mathematical models of natural disease progression, needed to conduct the economic analyses, are mostly based on high-income countries because the longitudinal data required for parameterization are unavailable in LMICs. We present a mathematical methodology specific for LMICs.

4 - Analytics-Based Advances in Organ Assessment and the Transplantation Decision-Making Implications

Ran Jin, Virginia Tech, Blacksburg, VA, United States, jran5@vt.edu, Qing Lan, Christian Wernz, John Robertson

Many viable organs were discarded due to ineffective assessment and conservative standards in transplantation. In addition, current assessment methods, biopsy and visual inspection, are subjective. This study is to create objective and non-invasive viability assessment methods for transplantation, leading to effective organ matching decisions. Therefore, we propose to use infrared images and spatio-temporal data analysis to predict viability and identify suspected regions for future biopsy. We validate the method by using porcine livers and kidneys. Our proposed methods can potentially secure discarded organs for transplantation to benefit more end-stage patients with organ failure.

■ TD24

CC- Room 3B

Behavioral Decision Analysis II

Sponsored: Decision Analysis

Sponsored Session

Chair: Gilberto Montibeller, Loughborough University, Loughborough, LE11 3TU, United Kingdom

1 - Evaluation of Visual Analytics in Group Decision Support Systems

Hugo Tsugunobu Yoshida Yoshizaki, University of Sao Paulo, R. Paulo F. Costa Aguiar 1600 Ap 161 G, Vila Yara, Osasco, 06026-090, Brazil, hugo@usp.br, Filippe A. Santos, Gilberto Montibeller, Matthias Winkenbach

Location decisions are complex with multiple and conflicting objectives and a spatial dimension which made this kind of problem particularly attractive to use visual analytics. We developed a group decision support system to study how effective decision makers are to explore the decision space through visual interaction. To answer to which extent the GDSS provides effective decision support, we present how we are testing the system using behavioral role-playing simulations.

2 - Using Signal Detection Theory to Characterize Trade-offs Between Deterrence and Vulnerability Reduction in Security Screening

Richard S. John, Professor, University of Southern California, Dept. of Psychology MC 1061, Los Angeles, CA, 90089-1061, United States, richardj@usc.edu, Nicholas Scurich, William Burns

Signal Detection Theory (SDT) provides a framework for partitioning people entering security screening based on an individual risk assessment from available information. Depending on the base-rate of adversaries and relative error penalties, SDT prescribes an optimal threshold score for classifying individuals as “high-risk” or “low-risk” for purposes of screening. One deviation from the SDT fixed threshold approach is to use a randomization method that increases the likelihood of a “high-risk” screening with increased risk assessment. Such randomization approaches are useful only if the decreased threat from deterrence is greater than the increase in vulnerability.

3 - Making Decisions and Gaining Buy-in in Polarized Times

Patrick Leach, Adjunct Professor / Independent Consultant, Colorado School of Mines, Denver, CO, 80202, United States, leach.sullivan@gmail.com

People naturally seek out and believe evidence that supports their current beliefs and deny evidence that contradicts those beliefs. Liberals, conservatives, and libertarians weight and interpret basic human values differently. When people with similar views discuss a subject in a group, the group’s views become more extreme than the most extreme individual’s view prior to the discussion. Social media exacerbates this problem. How is one to make decisions, let alone gain buy-in from diverse groups in today’s polarized world? Evidence alone doesn’t change minds; there must also be an emotional appeal. This talk will discuss these problems and conclude with possible approaches to mitigating them.

4 - Which Biases Matter in Decision and Risk Analysis?

Gilberto Montibeller, Loughborough University, School of Business & Economics, Loughborough, LE11 3TU, United Kingdom, g.montibeller@lboro.ac.uk, Detlof von Winterfeldt

Behavioral decision research has identified a plethora of cognitive biases that affect judgments of experts and decision makers. Biased judgments may cause detrimental impacts on the quality of decision and risk analysis models, distorting results and invalidating recommendations. But do all these biases really matter for decision and risk analyses? We argue that some biases are more relevant than others and suggest a list of criteria that identify whether a bias is relevant. This framework may help decision analysts in identifying existing biases that are more relevant, detecting if new found biases might be relevant, and guiding efforts to debias those ones that are indeed the most relevant ones.

■ TD25

CC- Room 401

OR in Taiwan

Emerging Topic: Practice Curated Track

Emerging Topic Session

Chair: Kuo-Hao Chang, National Tsing Hua University, Hsinchu, 30013, Taiwan

Co-Chair: I-Lin Wang, National Cheng Kung University, Industrial Information Management, Tainan, 70101, Taiwan

1 - An Efficient Framework Conditional-Expectation-based Simulation Optimization

Kuo-Hao Chang, National Tsing Hua University, Industrial Engineering, Hsinchu, 30013, Taiwan, Hsing-Yu Lin

Conditional value at risk (CVaR) is a widely used risk measure commonly applied by financial engineers. This paper generalizes CVaR research by developing a simulation optimization framework capable of efficiently calculating and optimizing the conditional expectation without requiring gradient information or convexity assumptions. An extensive numerical and empirical studies are conducted to demonstrate the efficiency and efficacy of our proposed method.

2 - The Integrated Bus Driver Scheduling and Rostering Problem

Dung-Ying Lin, National Tsing Hua University, Transportation Management, Tainan City, Taiwan, Chieh-Ju Juan

In the public bus transportation industry, crew management is typically decomposed into two phases: crew scheduling and crew rostering, due to the complexity when considering both procedures simultaneously. In the research, we formulate the two problems into an integrated model and propose a Branch-and-Price-and-Cut (BPC) algorithm to solve the compound problem. To validate the effectiveness and evaluate the efficiency of the proposed solution frameworks. In the numerical results, we test six groups data with different number of working tasks. The results show that the BPC algorithm performs well and can solve problems of realistic size within reasonable computational time.

3 - Search Path Planning for a Randomly Distributed Immobile Target using Fleet of UAVs with Battery Swapping Stations

I-Lin Wang, National Cheng Kung University, Industrial Information Management, 1 University Road, Tainan, 70101, Taiwan, Yen-Wei Chen

Conventional optimal searcher path problem seeks an immobile target on a network, where each arc is associated with a probability for that target. The searchers need to travel all arcs with constant speed aiming at a minimal expected time of finding the target. In our research, we use a fleet of UAVs together with pre-installed battery swapping stations to do the search job. UAVs have two travel modes: a search mode and a fly mode with different speeds and power consumption. Math programming models and solution methods will be discussed.

4 - A Network Flow Model for Scheduling Advance Reservations of Shared Parking

Chung-Cheng Lu, Professor, National Chiao Tung University, Chung-Hsiao West Road, National Chiao Tung University,, Taipei, 100, Taiwan, jasoncclu@gmail.com, Yun-Chu Hung

Shared parking is a type of parking management that aims to efficiently utilize parking spaces in urban areas. Through shard parking, private parking owners can rent out their parking space at times they don't use it. This allows drivers to park their car at parking spaces that are so far not accessible for them, and hence may help drivers to avoid the long search and the circling around to find an empty parking space. This paper addresses the scheduling problem of advance reservations for shared parking systems. We formulate the scheduling problem as a mixed integer linear program (MILP) based on an innovative parking space-flow network.

5 - Healthcare Scheduling Policies in Taiwan: Squeezing Physicians' Utilization from a Sequence-number based Appointment System

I-Hsuan Hong, National Taiwan University, Industrial Engineering, Taipei, 106, Taiwan, Pei-Sheng Cheng

The hospitals or clinics in Taiwan adopt the sequence-number based appointment system, where the physician's office provides each outpatient a specific number with a suggested arrival time on a first-call, first-appointment basis. This study investigates two appointment scheduling patterns and three late arrival policies with the consideration of outpatients' behaviors on the basis of expectation and past experience. The results indicate that a plateau-dome scheduling pattern and a three-queue late arrival policy significantly reduce waiting time compared with a uniform scheduling pattern and other used late arrival policies.

■ TD26

CC- Room 4C-1

Service Analytics and Applications

General Session

Chair: Srinivasa Prasanna, IIIT-Bangalore, 26/C, Hosur Road, Electronics City, Opposite Infosys Technologies, Bangalore, 560100, India

Co-Chair: Abhilasha Aswal, International Institute of Information Technology, 26/C Electronics City, Hosur Road, Bangalore, 560100, India

Co-Chair: Anushka Chandrababu, International Institute of Information Technology, Bangalore, India

1 - Analytics and Edge Computing for Public Safety

Vidya Sagar, Spectronn, Holmdel, NJ, United States

Public safety concerns have heightened in the recent decades. Additionally, the agencies dealing with it have to adopt technologies like AI, Edge computing and IoT. At Spectronn, we help federal and state public safety agencies in this transition. This talk shares our experiences and discusses the challenges faced.

2 - Analytics for Financial Services

Ravi Venktaratna, Infosys Limited, Bangalore, India

We illustrate the issues involved in Financial Services. Mainly the issues in controlling access, maintaining database sanity, and providing high performant simple and complex services to 50 to 100 million customers. The talk will focus on general aspects in the most part, but specific examples from industry will be included.

3 - Challenges and Solutions for Problems in a Large National Railway System

Srinivasa Prasanna, IIIT-Bangalore, 26/C, Hosur Road, Electronics City, Opposite Infosys Technologies, Bangalore, 560100, India, Abhilasha Aswal

Indian Railways is the world's largest rail network, if complexity is taken into account. The system operates 20,000 passenger trains per day, and the complexity is one to two orders of magnitude larger than some of the largest Airlines in the world. The system provides both unreserved and reserved tickets, and given its scale, is fairly efficient. In this talk, we will illustrate the issues involved in serving a billion+ people, as the nation's main transportation lifeline. Issues are challenging from reservations of tickets, all the way to rolling stock and cargo logistics.

4 - Service Analytics for Airline Scheduling

Ganesh Perumal, Sabre, Bangalore, India

In this talk we illustrate issues in service delivery for airline scheduling. We illustrate the scale and stringent quality requirements, in the presence of uncertainties in aircraft arrival/departure, congestion at airports etc. We shall illustrate some generic algorithmic issues with at least one real life to scale example.

5 - Issues and Challenges in Service Analytics in a Nutshell

Anushka Chandrababu, International Institute of Information Technology, 26/C, Electronic City, Bangalore, India

In this talk we will present a sum-up of the session and comment on the recent advances in Service Analytics along with the current challenges.

■ TD27

CC- Room 4C-2

Portfolio Analysis & Politics/Voting

Contributed Session

Chair: Shilpi Mukherjee, Clemson University, Clemson, SC, 29631, United States

1 - Construction of Smart Beta Index under a Non-normal Return Distribution

Rei Yamamoto, Keio University, Kohoku-ku, Japan, Naoya Kawadai

We focus on the "Rachev ratio" proposed by Biglova et al. (2004) and propose a new smart beta index using it. This ratio has demonstrated its effectiveness as a performance measure; however, it is difficult to consider it to be a portfolio tool, particularly due to its nonconvexity. Therefore, we propose a simple weighting method to construct a portfolio, transforming it into a new smart beta index. Moreover, we compare its performance with other smart beta indices in the global stock markets. Hence, we conclude that this smart beta is a new effective index that can be used in global stock markets.

2 - Statistical Assessment of Momentum-based Scenarios for Stock Index Returns and Levels

Xiaoshi Guo, Iowa State University, Ames, IA, United States, xsguo@iastate.edu, Sarah M. Ryan

We investigate how well stock index observations are represented by scenario time series generated according to a variant of geometric Brownian motion that incorporates return momentum and changing volatility. Multiple scenarios of index returns and levels are generated on a rolling basis by Monte Carlo simulation for use in stochastic optimization. In historical backtesting, uniformity of a mass transportation rank histogram is used to test a null hypothesis that the generated scenarios are indistinguishable from observed data. The hypothesis is not rejected for plausible combinations of future time horizons covered by the scenarios and past time horizons used for estimating parameters.

3 - Generating Natural Parson-Trip Data by Using Markov Model with Open Statistical Data

Reimi Shimizu, Waseda University, Tokyo, Japan, Takashi Hasuike

In japan, it is a serious problem that the number of people who has no public transport access is becoming to be large because of the aging society and depopulation, especially in the suburbs. To improve this situation, we have to develop the sustainable public transport access and before that, we need to understand the traffic demand. While the person-trip survey which investigates human movements is one of the most valuable data to consider, much less investigates has been done in the suburbs. In this paper, we propose the way of generating the natural parson-trip data by using the open statistical data which is easy to get and include no privacy data.

4 - Understanding Political Polarization Through Twitter Data

Shilpi Mukherjee, Graduate Research Assistant, Clemson University, Clemson, SC, United States, shilpim@clemson.edu, Patrick Warren

We have tried to look at political polarization between Democrats and Republicans in United States of America, by analyzing their tweets. There is an extensive literature suggesting that political polarization has increased since the Cold War. We employ a number of natural language processing techniques to understand this effect.

■ TD29

CC- Room 4C-4

Learning in Online Markets and Platforms

Sponsored: Auction and Market Design

Sponsored Session

Chair: Vijay Kamble

1 - Meta Dynamic Pricing: Learning Across Experiments

Ruihao Zhu, MIT, Cambridge, MA, 02139, United States, David Simchi-Levi, Hamsa Sridhar Bastani

We study the problem of learning shared structure across a sequence of dynamic pricing experiments for related products. We consider a practical formulation where the unknown demand parameters for each product come from an unknown distribution (prior) that is shared across products. We then propose a meta dynamic pricing algorithm that learns this prior online while solving a sequence of Thompson sampling pricing experiments (each with horizon T) for N different products.

2 - Integrated Online Learning and Adaptive Control in Queueing Systems with Uncertain Payoffs

Jiaming Xu, Duke University, Durham, NC, United States, jiaming.xu868@duke.edu, Wei-Kang Hsu, Xiaojun Lin, Mark Bell

We study task assignment in online service platforms where unlabeled clients arrive stochastically and each client brings a random number of tasks. As tasks are assigned to servers, they produce client/server-dependent random payoffs. The goal is to maximize the expected payoff subject to the servers' capacity constraints. However, both the statistics of the client population and the client-specific payoff vectors are unknown. We propose a new algorithm that seamlessly integrates online learning (of the clients' payoff vectors) with adaptive control (of the queueing system). Our analysis characterizes the payoff gap of our proposed algorithm in a finite time horizon compared to an oracle.

3 - Nonparametric Contextual Bandits in an Unknown Metric Space

Christina Lee Yu, Cornell University, Ithaca, NY, United States, cleeyu@cornell.edu, Nirandika Wanigasekara

Consider a nonparametric contextual multi-arm bandit problem where each arm is associated to a nonparametric reward function mapping from contexts to the expected reward. Suppose that there is a large set of arms, yet there is a simple but unknown structure amongst the arm reward functions, e.g. finite types or smooth with respect to an unknown metric space. We present a novel algorithm which learns data-driven similarities amongst the arms, in order to implement adaptive partitioning of the context-arm space for more efficient learning. We provide regret bounds along with simulations that highlight the algorithm's dependence on the local geometry of the reward functions.

4 - Semi-Parametric Dynamic Contextual Pricing

Virag Shah, Stanford University, Management Science and Engineering, Stanford, CA, 94305, United States, virag@stanford.edu, Jose Blanchet, Ramesh Johari

We consider the problem of revenue-maximization in a setting where the seller can leverage contextual information describing the customer's history and the product's type to predict her valuation of the product. However, her true valuation is unobservable to the seller, only binary outcome in the form of success-failure of a transaction is observed. Unlike in usual contextual bandit settings, the optimal price/arm given a covariate in our setting is sensitive to the detailed characteristics of the residual uncertainty distribution. We develop a semi-parametric model in which the residual distribution is non-parametric and provide the first learning algorithm with \tilde{O}(\sqrt{n}) regret.

5 - Data-adaptive Model Selection in Online Learning

Vidya Muthukumar, University of California, Berkeley, Berkeley, CA, United States, Mitas Ray, Niladri Chatterji, Anant Sahai, Peter L. Bartlett

We consider sequential learning with full information and bandit (limited-information) feedback, models used in platforms for online advertisement placement, repeated auctions, wireless channel allocation and mobile healthcare. Theoretical guarantees are traditionally obtained in the form of (worst-case) regret with respect to a fixed offline benchmark. However, to maximize overall reward the choice of offline benchmark matters as much as the choice of regret minimizing algorithm. We motivate that this choice should be adapted in an online fashion according to the data itself, and provide algorithmic approaches to do this in contextual prediction with both full-information and bandit feedback. We obtain regret/reward bounds that are almost as good as an optimal algorithm which has oracle knowledge of the existence of stochasticity *and* the right generative model for the data. Our techniques involve adversarially robust adaptations of statistical tools — structural risk minimization, validation and hypothesis testing — to the sequential setting.

■ TD29a

CC- Room 400

Modeling and Optimization

Contributed Session

Chair: Robert Koo, DoD, 99-793 Holoai St, Aiea, HI, 96701, United States

1 - Feature Extraction on Motor and Non-motor Assessments for Parkinson's Disease: Using Transformed Features to Characterize and Correlate Subtypes

Robert Koo, DoD; University of Hawaii, Honolulu, HI, United States, r.koo@hotmail.com, Suzanne Tsukenjo

Parkinson's Disease (PD) is a progressive neurodegenerative disorder that is defined by both motor and non-motor symptoms. Clinicians use a broad range of motor/non-motor assessments to characterize the subtype and severity of PD. Using big data from the Parkinson's Progression Markers Initiative (PPMI), this study focuses on the extraction of latent features from motor/non-motor assessments in order to establish meaningful characterization of PD subtypes and how transformed features correlate with baseline biospecimen data. Clinical assessment and biospecimen data from over 600 PD and Healthy Control subjects are analyzed through classical and modern machine learning techniques.

2 - A MCDM Method for Experts Assessment of Hospitals Quality

Diogo Ferreira, Universidade de Lisboa, Lisbon, Portugal, diogo.cunha.ferreira@tecnico.ulisboa.pt, José Rui Figueira, Salvatore Greco, Rui Marques

The object of this study consists of the performance assessment of some reference hospitals based on several experts and their judgments about the quality of these hospitals. From such qualitative assessments, we infer a preference model of the experts, which can be used for assessment of the quality of the non-reference hospitals. This is a multicriteria machine learning based tool, which proposes an overall value for each hospital. The expert judgments are provided for each criterion as well as each sub-criterion. Judgements are usually expressed through ordinal scales.

3 - Evaluation of Fiscal Policies for Electric Vehicles - A Multicriteria Sorting Approach

Maria Isabel Clímaco, ISCAC - Coimbra Business School, Coimbra, Portugal

The growing share of electric vehicles will make a decisive contribution to the decarbonization of the economy. The importance of road transportation in economic, environmental and energy dimensions requires the assessment of the impact of existing and prospective fiscal policies on the promotion of electric mobility. The evaluation of a set of fiscal policies is performed as a sorting problem, i.e. the assignment of policies to predefined categories of merit according to multiple criteria, using the ELECTRE TRI method based on an outranking relation allowing non-compensation effects.

4 - Using JSON and NoSQL Databases to Deliver Data for Deploying Optimization Models through REST API Service on the Cloud

Bjarni Kristjansson, Maximal Software Inc., Arlington, VA, 22201, United States

When preparing optimization models for deployment, it is often not the formulation of the model or the solving that is the most difficult part, but rather how to organize and deliver the data efficiently to the model. Using modeling languages, this problem can be alleviated by importing data directly from SQL databases and spreadsheets, but this is still not easy enough. In this presentation, we will demonstrate how using the JSON data format can be particularly well suited for organizing optimization data. Furthermore, using NoSQL databases such as MongoDB and DynamoDB, which are very efficient at storing dynamic data, give the model developer new opportunities for deploying optimization on the cloud.

■ TD30

CC- Room 6A

Tutorial: The Use of Data Science for Supply Chain Transportation Management

Emerging Topic: Tutorials

Emerging Topic Session

1 - Tutorial - The Use of Data Science for Supply Chain Transportation Management

Samuel K. Eldersveld, Amazon.com, Seattle, WA, 98112, United States, Elcin Cetinkaya

Recent developments have motivated data science targeting improvements in supply-chain execution. We present techniques for three large-scale transportation problems with the goal of providing exceptional customer service and hitting targets on cost, flexibility, and speed. 1. Models for containerization used in a hub-and-spoke supply-chain network which generate pre-sorting splits for a class of distinct containers destined for fulfillment centers. 2. Efficient forecasts of package demand using multi-model inference targeting both middle-mile and last-mile transportation systems. 3. Risk prediction using large-scale machine learning models to account for weather anomalies.

■ TD31

CC- Room 6B

Advances in Cybersecurity Analytics and Data Science

Sponsored: Military and Security

Sponsored Session

Chair: Nathaniel D. Bastian, PhD, Army Cyber Institute, U.S. Military Academy, West Point, NY, 10918, United States

Co-Chair: Andrew Oscar Hall, United States Military Academy, West Point, NY, 10996, United States

1 - Adversarial Machine Learning in the Network Intrusion Detection Setting

Elie Alhajjar, Cyber Mathematics Fellow, Army Cyber Institute, U.S. Military Academy, 68 Corbin Hill Road, West Point, NY, 10922, United States, eliealhajjar@gmail.com, Nathaniel D. Bastian, Paul Maxwell, Robert Thomson, Malcolm Haynes

In the past couple of years, it has become common knowledge that neural networks are vulnerable to any type of perturbation. This issue is hindering the application of machine learning techniques in mission-critical situations. In this talk, we investigate this phenomenon in the network intrusion detection setting. We highlight the similarities and the differences with image recognition through real data sets experiments. We focus on generating adequate perturbations to the data in hand and how this process impacts classification of network flows. Time permitting, we discuss a Generative Adversarial Network (GAN) approach to the problem of identifying benign packets.

2 - Intelligent Feature Engineering for High-Performance Computing Enabled Machine Learning in Cybersecurity

Paul Maxwell, PhD, Army Cyber Institute, U.S. Military Academy, West Point, NY, United States, Elie Alhajjar, Nathaniel Bastian

Feature engineering and selection is a critical step for any machine learning system. In application areas like cybersecurity intrusion detection, this task is made more complicated by the diverse data types and ranges. Previous efforts in this area naively apply techniques for feature engineering that were successful in image recognition. We use network packet data from the Defense Research and Engineering Network and the Engineer Research and Development Center's high performance computing systems to analyze methods of feature engineering and selection. The results are compared to previous machine learning studies on intrusion detection to provide insight on the suitability of the features.

3 - Robust Goal Programming to Optimize Army Cyber Branch Readiness and Manning under Uncertainty

Brian J. Lunday, Associate Professor, Air Force Institute of Technology, Department of Operational Sciences, WPAFB, OH, 45433, United States, brian.lunday@afit.edu, Nathaniel D. Bastian, Chris Fisher, Andrew Oscar Hall

We proffer the Robust Cyber Force Manning Model (R-CFMM), an advanced analytics framework that uses a robust goal programming approach to enable the modeling, experimentation and optimization necessary to help solve the Army's Cyber Workforce Planning Problem. Particularly, the R-CFMM helps optimize the readiness of the Army's Cyber Branch by effectively projecting the optimal number of personnel needed to meet the demands of the current force structure under conditions of uncertainty in personnel retention.

4 - A Quantitative Risk Analysis of Nation State Supported Computational Propaganda

Travis Trammell, Stanford University, Stanford, CA, 94305, United States

Strategically using information to affect the views of a population is certainly nothing new and dates all the way back to the earliest development of political systems. The rapid distribution of fake news can cause contagion, manipulate markets, spark conflict, or fracture strategic relations. Probabilistic Risk Analysis(PRA) can be leveraged to quantitatively describe the risk associated with fake news by examining all relevant factors. Additionally, optimization of the methods to execute computational propaganda, ranging from embedding bots into online social echo chambers to selecting the most polarizing content,represents a new frontier in the information warfare arena.

5 - A Machine Learning Approach to Robust Malware Classification under Adversarial Conditions

Nathaniel D. Bastian, Operations Research Scientist, Army Cyber Institute, U.S. Military Academy, 34 Booth Road, West Point, NY, 10918, United States, nathaniel.bastian@westpoint.edu, Sean M. Devine

In an environment characterized by widespread accessibility and big data, the feasibility of malware classification without the use of artificial intelligence-based techniques has been diminished exponentially. The threat of adversarial machine learning also poses challenges, as adversaries are looking to target the underlying data and/or algorithm responsible for the functionality of malware classification to map its behavior or corrupt its functionality. The ends of such adversaries are bypassing the cyber security measures and increasing malware effectiveness. This work employs a machine learning approach to accurately, robustly classify malware under adversarial conditions.

■ TD32

CC- Room 6C

Biotechnology/Bioinformatics

Contributed Session

Chair: Arsenios Tsokas, University of Florida, Gainesville, FL, 32611, United States

1 - STADIA: A Machine Learning Based Tool for Analyzing Dynamic Instability of Microtubules

Shant M. Mahserejian, Research Scientist, Pacific Northwest National Laboratory, Richland, WA, United States, shant.mahserejian@pnnl.gov, Jared Scripture, Ava J. Mauro, Erin M. Jonasson, Jun Li, Mark S. Alber, Holly V. Goodson

Microtubules (MTs) are cytoplasmic bio-polymers with a well-known behavior, dynamic instability (DI), characterized by switches between growth and shortening via transitions called catastrophe and rescue. We present the Statistical Tool for Automated Dynamic Instability Analysis (STADIA) to more accurately measure DI parameters, classify phases, and analyze patterns in high-resolution data sourced from either experiment or simulation. Through unsupervised machine learning, STADIA revealed “stutters”, a transient phase prevalent during catastrophes, which could help explain the structural mechanisms behind DI phase transitions.

2 - Applications of Machine Learning Methods to Maize Genetics and Plant Breeding

Emre Cimen, Institute for Genomic Diversity, Cornell University, Ithaca, NY, United States, ec796@cornell.edu
Emre Cimen, Computational Intelligence and Optimization Laboratory, Eskisehir Technical University, Eskisehir, Turkey, ec796@cornell.edu, Joseph Gage, Sarah E. Jensen, Maria Katherine Mejia-Guerra, Jacob Washburn, Edward S. Buckler

Nowadays, machine learning based methods are applied to almost all science and technology fields, and they help us to make better predictions and to discover hidden information. In this study, specific applications of machine learning methods to maize genetics and plant breeding are examined. Optimal growth temperature prediction, genotype and environment (G×E) based yield prediction, transcription factor (TF) prediction, and field effect prediction applications are defined as classification, regression, and feature selection problems. Opportunities and barriers of these applications are discussed.

3 - New Algorithms for Detecting Multi Effects and Multi Ways Epistatic Interactions

Javad Ansarifar, Iowa State University, Ames, IA, United States, ansarifar.javad@gmail.com, Lizhi Wang

Detection of epistasis, which is the phenomenon of genetic interactions, is extremely challenging problem due to the combinatorial nature of the problem. We propose three new algorithms for multi-effect and multi-way epistases detection, with one guaranteeing global optimality and the other two being local optimization oriented heuristics. The comparison of computational performance of the proposed heuristic algorithm with several state-of-the-art methods revealed the proposed heuristic algorithm was much more effective and efficient than others at finding a close-to-optimal solution.

4 - RFE-SVR Prediction Modeling for Microarray Gene Expression Analysis

Sharmin Nahar Mithy, Graduate Assistant, University of South Florida, Tampa, FL, United States, sharminmithy@mail.usf.edu, Grisselle Centeno, Susana Lai-Yuen

In the treatment of cancer patients, radiation therapy is most often applied before or after or pre-surgery to improve the local control of the disease and the survival rate of the patients. In this study, we explore the genomic information of patients in relation to the response of radiation therapy. We have developed a prediction model that is able to analyze the genomic expression data and predict SF2, which is a measure of the radiation response. For our research, we used RFE-SVR combination to first reduce the dimension of the features and then develop the model. The result has shown significant improvement in comparison with other explored statistical analysis published in the literature.

5 - Nephrotoxic Drug-Associated Acute Kidney Injury in Hospital Patients

Arsenios N. Tsokas, University of Florida, Gainesville, FL, United States, artsokas@ufl.edu, Panayote (Panos) M. Pardalos, Tezcan Ozrazgat-Baslanti, Azra Bihorac

Timely detection of Acute Kidney Injury (AKI) in hospital patients could avoid further injurious practices. In particular, if the probability of development of AKI is known to be high, administration of nephrotoxic drugs can be adjusted to prevent further complications. In this study, we evaluate the impact of nephrotoxic drugs on kidney condition. In a cohort of UF Health patients, daily status was classified with respect to AKI for each patient. Nested machine learning models are built and evaluated to investigate the association between use of nephrotoxic drugs and occurrence of Acute Kidney Injury the following day adjusting for demographic and operative data.

■ TD33

CC- Room 602

SCIP Optimization Suite: Recent Advances and Applications

Sponsored: Optimization/Computational Optimization and Software

Sponsored Session

Chair: Ambros Gleixner, Berlin, Germany

Co-Chair: Jakob Witzig, Berlin, Germany

Co-Chair: Gerald Gamrath, Zuse-Institut Berlin

1 - Using HiGHS as an LP Solver within SCIP

Julian Hall, University of Edinburgh, Peter Guthrie Tait Road, Edinburgh, EH9 3FD, United Kingdom, jajhall@ed.ac.uk

HiGHS is a growing open-source repository of high-performance software for linear optimization based on award-winning computational techniques for the dual simplex method. The use of HiGHS as an LP solver within SCIP is attractive since it out-performs Soplex on benchmark LP problems and is available via the MIT license. This talk will describe the challenges of achieving efficient performance via the standard SCIP interface, and analyse the performance of SCIP with HiGHS and Soplex as LP subproblem solvers.

2 - Reformulation Linearization Technique Cuts for Explicit and Implicit Bilinear Constraints

Ksenia Bestuzheva, Zuse Institute Berlin, Berlin, Germany, bestuzheva@zib.de, Tobias Achterberg, Ambros Gleixner

We present a method which applies the Reformulation-Linearization Technique to bilinear constraints, including those encoded within MILPs. These implicit bilinear relations are detected by finding linear constraints with a special structure. One drawback of RLT is the large number of cuts it produces, many of which are redundant. This is addressed in our algorithm by identifying early the combinations of problem rows and multipliers that will not produce violated cuts and thus can be ignored. The method is tested on both linear and nonlinear mixed-integer programming problems.

3 - Decomposing MINLPS and General Enhancement Techniques: Updates to the Benders' Decomposition Framework in SCIP

Steve Maher, University of Exeter, Exeter, United Kingdom

Benders' decomposition is a popular mathematical programming technique for solving large scale optimisation problems. While historically viewed as a problem specific algorithm, general frameworks provide an ideal platform to investigate general decomposition and algorithmic enhancement techniques. This talk will provide an update on the current developments for the Benders' decomposition framework available with SCIP and GCG. In particular, the extension of the methods to handle the decomposition of MINLPs and current work on general enhancement techniques will be discussed.

4 - Branching Improvements in SCIP

Gerald Gamrath, Zuse-Institut Berlin, Berlin, Germany

Branching is an essential component of state-of-the-art mixed-integer programming solvers. It splits the current problem into sub-problems for later evaluation; how this is done has an enormous impact on the solver performance. We report on our recent research on branching rules, including lookahead branching (multi-level strong branching) and the consideration of dual degeneracy in branching. All methods have been implemented in the academic MIP solver SCIP and evaluated by extensive computational experiments.

■ TD34

CC- Room 603

Constraint Programming Optimization and Logistics

Contributed Session

Chair: Leif Meier, HS Bremerhaven, Bremerhaven, Germany

1 - A Comparison of Constraint Programming and Mix Integer Programming in Solving Routing Problems

Tengkuo Zhu, The University of Texas at Austin, Austin, TX, United States, zhutengkuo@utexas.edu, Stephen D. Boyles

Constraint Programming (CP) has been applied to a variety of combinatorial optimization problems, most notably in scheduling applications. In other problems CP has also established itself as a competitor to state-of-art Mix Integer Programming (MIP) solvers. This work represents the comparison between these two approaches of their performance in solving routing problems, such as TSP, VRP and other variants of them. The paper explores the converging time and solution optimality of both approaches based on the test of numerous instances selected from the open-source TSPLIB and VRPLIB dataset.

2 - Optimizing Steel Manufacturing Process

Ali Esmail, Graduate Student, California State University of Fullerton, Anaheim, CA, United States, ali.esmail@csu.fullerton.edu, Hakob Avetisyan, Niranjan Mahamuni, Peter Jacoy, Zachary Chao

This research demonstrates the application of optimization theories can create feasible and practical solutions to achieve optimal production of steel, profits, and limit pollution in a steel manufacturing process. Procurement, inventory, production, administrative overhead, and low carbon footprint are the main factors to consider in order maintaining organizational stability in the construction industry. The results of this research indicate benefits for both large and small companies to increase profit and efficiency in the industry, and this model may assist companies to create a systematic approach by utilizing optimization theories and mathematical modeling.

3 - Managing Randomization in the Multi-block Alternating Direction Method of Multipliers for Quadratic Optimization

Mingxi Zhu, Stanford University, Stanford, CA, United States, mingxiz@stanford.edu, Kresimir Mihic, Yinyu Ye

The Alternating Direction Method of Multipliers (ADMM) has gained a lot of attention for solving large-scale constrained optimization. Enforcing a multi-block structure leads to computational efficiency. In this paper, we add randomness into the multi-block ADMM by developing a randomly assembled cyclic ADMM (RAC-ADMM) where the decision variables in each block are randomly assembled. We discuss the theoretical properties of RAC-ADMM and show when random assembling helps and when it hurts. Using the theoretical guidance on RAC-ADMM, we conduct multiple numerical tests. Our numerical tests show that RAC-ADMM could significantly improve the computation efficiency.

4 - Integrated Truck and Workforce Scheduling in Cross-Docks

Pascal Wolff, Technische Universität Darmstadt, Darmstadt, Germany, wolff@scnm.tu-darmstadt.de, Jiazhen Huo, Hans-Christian Pfohl

Besides its increasing practical relevance, cross-docking also received a lot of academic attention in the last two decades. A vast number of publications dealt with the determination of optimal truck schedules. However, most of the proposed models are detached from industry practice since they do not consider available workforce. In this paper, we address this research gap and propose novel model formulations which integrate the planning of truck and workforce schedules in a cross-dock. Furthermore, we present exact and heuristic solution approaches to tackle the problems.

5 - Reducing Forklift Congestion in an LTL Cross-docking Terminal

Vahid Ghomi, Penn State University at Mont Alto, Mont Alto, PA, United States, vahid.ghomi@gmail.com, Mina Ghofrani Esfahani

Tabu-search (TS) is used to solve a cross-docking quadratic assignment problem (CDAP). The model concerns to minimize the total weighted traveled distance (WTD) and congestion cost (WCC). Taguchi robust parameters settings is employed to achieve the best combination of the six signal factors while removing the effect of noise factors. Using the Taguchi method, we assume the smaller-the-better signal-to-noise ratio and TS's diversification methods are considered as noise factors. The result suggests that the best way to improve TS output quality is to start it from the best initial solution. Testing 45 instances, TS outperforms the hill-climbing and CPLEX solution.

6 - The Yard is the Heart - Analysing Yard Strategies to Match Container Terminal Business Strategies

Leif Meier, University of Applied Sciences Bremerhaven, Bremerhaven, Germany, lmeier@hs-bremerhaven.de

The yard strategy defines procedures and a methodology for a terminal to assign containers to a specific yard position. Yard management has been identified as a key competency of a container terminal to ensure an efficient container flow and customer requirements resulting in minimum handling costs and it must be aligned with the berthing strategy to minimize distances on the yard. We defined realistic yard filter sets and simulate resulting receival and delivery pattern to be matched against multiple criteria from business target functions.

■ TD35

CC- Room 604

Recent Advances in Discrete Optimization

Sponsored: Optimization/Integer and Discrete Optimization

Sponsored Session

Chair: Alfredo Torrico, ISyE Ga Tech, Atlanta, GA, 30332-0205, United States

1 - Intersecting Restrictions in Clutters

Gerard P. Cornuejols, Carnegie Mellon University, Tepper School of Business, Pittsburgh, PA, 15213-3890, United States, gc0v@andrew.cmu.edu

A clutter is intersecting if the members do not have a common element yet every two members intersect. It has been conjectured that for clutters without an intersecting minor, total primal integrality and total dual integrality of the corresponding set covering linear system must be equivalent. In this talk, we provide a polynomial characterization of clutters without an intersecting minor. This is joint work with Ahmad Abdi and Dabeen Lee.

2 - Minimum Spanning Trees on Infinite Graphs

Christopher Ryan, University of Chicago, Chicago, IL, 60637, United States

We discuss the problem of finding minimum spanning trees (MSTs) on graphs with countably many nodes and arcs. We find the naive extensions of greedy algorithms, familiar in the finite setting, do not necessarily converge to minimum spanning trees. We propose a non-greedy algorithm, that finds MSTs on finite subgraphs in each iteration, converge (possibly along a subsequence) to a spanning tree. This result, however, only holds for graphs that has no infinite length cycles.

3 - Semidefinite Programming Relaxations of the Traveling Salesman Problem

Samuel C. Gutekunst, Cornell University, Ithaca, NY, 06883, United States, scg94@cornell.edu, David P. Williamson

The traveling salesman problem (TSP) is a fundamental problem in combinatorial optimization. Several semidefinite programming (SDP) relaxations have been proposed recently that perform strongly in small computational tests; these experiments motivate theoretical interest in the SDPs. We characterize the worst-case performance of these relaxations by showing that several major TSP SDP relaxations have an unbounded integrality gap. To do so, we provide a family of simplicial TSP instances that form a litmus test for future SDP relaxations.

4 - Parallel Hypergraph Matching

Oussama Hanguir, Student, Columbia University, New York, NY, 10025, United States, oh2204@columbia.edu, Clifford Stein

As massive graphs become ubiquitous, the need for scalable algorithms that solve graph problems grows as well. We are interested in the Maximum Hypergaph Matching Problem in the massively parallel computation (MPC) model that is a common abstraction of MapReduce-style computation. This problem arises in many applications where we need to partition elements under strong constraints, including scheduling airline flight crews to airplanes or finding the optimal coalition in cooperative games. We present the first three algorithms for Hypergraph Matching in the MPC model, and we analyze them in terms of resources such as memory usage, rounds of communication needed, and approximation ratio.

■ TD36

CC- Room 605

Nonconvex Optimization in Machine Learning

Sponsored: Optimization/Optimization Under Uncertainty

Sponsored Session

Chair: Ethan Xingyuan Fang, Pennsylvania State University, University Park, PA, 16802, United States

1 - Towards understanding the Importance of Noise in Training Neural Networks

Tuo Zhao, Georgia Tech, NW, Atlanta, GA, 30332, United States, tourzhao@gatech.edu, Mo Zhou, Tianyi Liu, Yan Li, Dachao Lin, Enlu Zhou

Stochastic Gradient Descent-type (SGD) algorithms have been widely applied to many nonconvex problems in machine learning. In this talk, we propose to analyze the behavior of the SGD-type algorithms through a simple but nontrivial nonconvex problem - Training Nonoverlapping Two-layer Convolutional Neural Networks. Specifically, we show that in conjunction with noise annealing, perturbed-GD attains sublinear convergence to the global optimum with high probability. Our theory not only helps better understand SGD, but also provides new insights on more complicated nonconvex problems in machine learning.

2 - On the Global Convergence of Policy Optimization in Deep Reinforcement Learning

Zhaoran Wang, Northwestern University, Evanston, IL, United States, zhaoran.wang@northwestern.edu

Policy optimization (with neural networks as actor and critic) is the workhorse behind the success of deep reinforcement learning. However, its global convergence remains less understood, even in classical settings with linear function approximators. In this talk, I will show that coupled with neural networks, a variant of proximal/trust-region policy optimization (PPO/TRPO) globally converges to the optimal policy. In particular, I will illustrate how neural networks enable us to establish much stronger guarantees. (Joint work with Qi Cai, Boyi Liu, Zhuoran Yang)

3 - Variational Transport: A Convergent Particle-Based Algorithm for Distributional Optimization

Zhuoran Yang, Princeton University, Sherrerd Hall, Department of ORFE, Princeton, NJ, 08544, United States

We consider the problem of minimizing a functional defined over a family of probability distributions, where the functional is assumed to have a variational form. For this problem, we propose the variational transport algorithm, which approximately performs functional gradient descent over the manifold of probability distributions via iteratively pushing a set of particles. By characterizing both the statistical error of estimating the functional gradient and the computational error of optimization algorithm, we show that the proposed algorithm enjoys global convergence with high probability. This is based on a joint work with Zhaoran Wang and Yongxin Chen.

4 - Combinatorial Inference in Large-Scale Graphs

Junwei Lu, Harvard University, Cambridge, MA, United States

We present computationally efficient algorithms to test various combinatorial struc- tures of large-scale graphical models. In order to test the hypotheses on their topological structures, we propose two adjacency matrix sketching frameworks: neighborhood sketching and subgraph sketching. The neighborhood sketching algorithm is proposed to test the connectivity of graphical models. This algorithm randomly subsamples vertices and conducts neighborhood regression and screening. The global sketching algorithm is proposed to test the topological properties requir- ing exponential computation complexity, especially testing the chromatic number and the maximum clique. This algorithm infers the corresponding property based on the sampled subgraph. Our algorithms are shown to substantially accelerate the computation of existing methods. We validate our theory and method through both synthetic simulations and a real application in neuroscience.

■ TD37

CC- Room 606

Recent Advances in Stochastic Integer Programming

Sponsored: Optimization/Optimization Under Uncertainty

Sponsored Session

Chair: Rui Chen, University of Wisconsin, Madison, WI, United States

1 - On Solving Nonconvex Two-stage Stochastic Programs with Generalized Benders Decomposition

Can Li, Carnegie Mellon University, Pittsburgh, PA, United States, canl1@andrew.cmu.edu, Ignacio E. Grossmann

In this paper, we propose a generalized Benders decomposition-based branch and cut algorithm for solving two stage stochastic mixed-integer nonlinear programs (SMINLPs) with mixed binary first and second stage variables. At a high level, the proposed decomposition algorithm performs spatial branch and bound search on the first stage variables. Each node in the branch and bound search is solved with a Benders-like decomposition algorithm where both Lagrangean cuts and Benders cuts are included in the Benders master problem. The performance of the proposed algorithm is compared with a Lagrangean decomposition-based branch and bound algorithm.

2 - Value of Multistage Stochastic Programming in the Rolling-horizon Procedure: A Computational Study

Yongjia Song, Clemson University, Clemson, SC, United States, yongjis@clemson.edu, Murwan Siddig

In this talk, we will present an adaptive stochastic look-ahead algorithmic framework for sequential decision making under forecast ambiguity. We aim to investigate the value of multi-stage stochastic programming as a look-ahead policy within the rolling-horizon procedure. To facilitate such understanding, we employ a variety of computational tools within this framework to effectively balance various sources of errors and uncertainty that come from the underlying stochastic processes, the Monte Carlo samples generated to solve the SP models, and model approximations and aggregations. Preliminary results will be presented.

3 - Two-stage Stochastic Conic Mixed Integer Programs

Manish Bansal, Virginia Tech, Blacksburg, VA, United States, bansal@vt.edu

In this talk, we present our recent advances on solving two-stage stochastic conic mixed integer programs.

4 - A New Cutting Plane Approach for Approximately Calculating the Lagrangian Dual of a Stochastic Integer Program

Rui Chen, University of Wisconsin-Madison, Madison, WI, United States, rchen234@wisc.edu, James Luedtke

We propose a new cutting plane approach for approximately calculating the nonanticipative Lagrangian dual bound of a two-stage stochastic integer program. We develop a family of cuts for the Benders master problem that can be generated by solving single scenario integer programs. We show that optimizing the Benders master problem with all of these cuts added yields the Lagrangian dual bound. Judicious use of these cuts within a branch-and-cut framework could lead to faster convergence. Preliminary computational results demonstrate the strength of the proposed approach in comparison with some existing decomposable methods.

■ TD38

CC- Room 607

Risk-Averse Stochastic Programming: Theory and Applications

Sponsored: Optimization/Optimization Under Uncertainty

Sponsored Session

Chair: Weijun Xie, Virginia Tech, Blacksburg, VA, 24061, United States

1 - Risk Aversion to Parameter Uncertainty in Markov Decision Processes

Merve Merakli, Northwestern University, Evanston, IL, United States, merakli@northwestern.edu, Simge Kucukyavuz

In classical Markov Decision Processes (MDPs), action costs and transition probabilities are assumed to be known, although an accurate estimation of these parameters is often not possible in practice. This study addresses MDPs under cost and transition probability uncertainty and aims to provide a mathematical framework to obtain policies minimizing the risk of high long-term losses due to not knowing the true system parameters. To this end, we utilize the risk measure value-at-risk associated with the expected performance of an MDP model with respect to parameter uncertainty. We provide mixed-integer linear and nonlinear programming formulations and heuristic algorithms for such risk-averse MDPs under a finite distribution of the uncertain parameters. Our proposed models and solution methods are illustrated on an inventory management problem for humanitarian relief operations during a slow-onset disaster.

2 - Zeroth-order Algorithms for Risk-averse Optimization

Dionysios S. Kalogerias, Princeton University, Charlton Street, Princeton, NJ, 08544, United States, dkalogerias@princeton.edu, Warren B. Powell

We present Free-MESSAGEp, the first zeroth-order algorithm for optimizing convex mean-semideviation risk functions, which is also the first zeroth-order compositional stochastic optimization algorithm, whatsoever. Using a non-trivial extension of Nesterov's results on Gaussian smoothing, we develop the Free-MESSAGEp algorithm on a smoothed version of our problem, and we explicitly relate it to the original problem. We then present a complete analysis of the Free-MESSAGEp algorithm, which shows convergence in a tunable neighborhood of the optimal solutions of the original problem, essentially striking a certain balance between problem dimensionality and algorithmic implementation.

3 - Finding Minimum Volume Ellipsoids Using Copositive Programming with an Application to Risk-averse Stochastic Programming

Grani Adiwena Hanasusanto, The University of Texas at Austin, Austin, TX, 78712, United States, Areesh Mittal

We study the problem of finding an ellipsoid of minimum volume that contains a given convex set. We reformulate the problem as a copositive program and use that reformulation to derive tight, tractable semidefinite approximations. We prove that our method never provides an ellipsoid of higher volume than the one obtained by scaling the maximum volume inscribed ellipsoid. We empirically demonstrate that our method generates high-quality solutions faster than solving the problem to optimality and outperforms the existing schemes in terms of solution time and quality. We present an application in the design of improved decision rule approximations for two-stage problems with random recourse.

4 - A Geometric Branch and Bound Method for Concave Robust Optimization with Functional Form Uncertainty

Sanjay Mehrotra, Northwestern University, Evanston, IL, 60208-3119, United States, mehrotra@iems.northwestern.edu, Fengqiao Luo

We study the minmax optimization problem where the inner problem is defined over a set of concave functions. These problems are significantly harder than the models where the inner problem is defined over a set of convex functions. For the case where the functions specifying the inner problem are piecewise linear, we give a mix-integer formulation of the model. We then present a novel geometric branch-and-bound method that systematically explores the feasible solutions. This method is extended to the case of more general concave functions. Computational results show that the proposed B&B method performs significantly better than the MIP formulations of the problem for the piecewise linear case.

■ TD39

CC- Room 608

Joint Session RAS/Practice Curated: Railroad Maintenance

Sponsored: Railway Applications

Sponsored Session

Chair: Qing He, University at Buffalo, SUNY, Buffalo, NY, 14260, United States

1 - Rail Service Failure Analysis: A Data-drive Approach

Faeze Ghofrani, University at Buffalo, Buffalo, NY, 14228, United States, Seyedsina Yousefianmoghadam, Qing He, Andreas Stavridis

In maintenance planning of rail track, it is essential to assess the potential of service failures. In the present study a new method is proposed to study the factors affecting the risk of rail service failures. The method is applied to the prediction of service failures for a US Class I Railroad. The outcome of this study, along with necessary future developments to broaden the scope of applicability of the method, will benefit railroad existing practice in capital and maintenance planning.

2 - Joint Optimization of Track Maintenance and Renewal Planning

Reza Mohammadi, University at Buffalo, Amherst, NY, 14228, United States, rm245@buffalo.edu, Qing He

We propose a data-driven robust optimization approach for joint planning of track maintenance and renewal activities. The optimization problem is formulated as a mixed integer programming model that maximizes the quality index of the track. This approach captures the uncertainty of the maintenance effects using a data-driven method and builds a robust mathematical model based on that uncertainty. Numerical results demonstrate clear trade-offs between maintenance and renewal activities to achieve the optimal track quality index.

3 - Using Smartphones to Assess Vehicle Running Quality and Track Conditions of Urban Rail Transit

Qing He, University at Buffalo, SUNY, Buffalo, NY, 14260, United States, qinghe@buffalo.edu, Jianli Cong

This paper uses smartphones as an inspection device in urban rail transit to evaluate the vehicle running quality and track conditions. Also, this paper proposes a data-cleaning method and a coordinate alignment method for processing smartphone collected data. The location of placing the smartphone in the car has been examined.

4 - Machine Learning for Predictive Maintenance of Positive Train Control (PTC) System

Clark Cheng, Chief Data Scientist, Norfolk Southern Corporation, Atlanta, GA, 23510, United States, Clark.Cheng@nscorp.com, Mabby Amouie, Ilya Lavrik

To ensure safe operations, freight railroads in North American have adopted positive train control (PTC) which is an advanced system designed to automatically stop a train before an accident occurs. Norfolk Southern has spent over $1.7 billion implementing PTC on about 8,000 miles of rail network. Given the importance and complexity of PTC, we developed a machine learning approach to predicting potential failures. In this presentation, we'll describe the methodology and results.

5 - Optimizing Conditioned-Based Maintenance and Investment in Shared Freight and Passenger Corridors

John F. Betak, Managing Member, Collaborative Solutions LLC, 726-23 Tramway Vista Dr NE, Albuquerque, NM, 87122, United States, john@collaborativesolutionsllc.com, Trefor P. Williams

In the US, most intercity passenger service track is in shared use corridors. This paper combines four methodological approaches to optimize condition-based track maintenance and investment in this environment; 1) automated text analysis; 2) calculated conditional probabilities in network-level scheduling problems; 3) integrating track inspection optimization models with ERM optimization models; 4) advanced data visualization techniques for decision support systems.

■ TD40

CC- Room 609

Joint Session Opt Nonlin/I-Sim:Simulation-Based Optimization and Design of Experiments

Sponsored: Optimization/Nonlinear Programming

Sponsored Session

Chair: Sven Leyffer

Chair: Mohan Krishnamoorthy

Chair: Sara Shashaani, North Carolina State University, Raleigh, NC, 48105, United States

1 - Bi-level Optimization for Design of Experiments

Mohan Krishnamoorthy, Argonne National Laboratory, Lemont, IL, 60439, United States, mkrishnamoorthy@anl.gov

We propose a bi-level optimization approach where in the upper level, we solve an optimization problem that chooses the experimental parameters using DFO. In the lower level, we solve an inverse problem to match observations to a model whose gradients are not available. Instead of relying on data generated through Monte-Carlo (MC) simulations, we propose an approach that approximates the parameters of the model as a pole-free rational function, which is obtained through an optimization formulation with structural constraints. Results show significant improvement in quality of tunes and the rational approximation are of high quality while being significantly more efficient than MC simulations.

2 - Decomposition in Simulation-based Optimization

Kaiwen Ma, Carnegie Mellon University, Pittsburgh, PA, United States, Nikolaos Sahinidis, Sreekanth Rajagopalan, Satyajith Amaran, Scott Bury

We propose a novel decomposition framework for simulation-based optimization. Our framework significantly extends the scope of current simulation-based solvers to larger-scale problems. We address several key questions, including how to select variables for each subproblem, and how to determine sub-problem dimension and sub-problem function evaluation limits. A practical implementation is developed and exemplified with the global model-based solver Stable Noisy Optimization by Branch and Fit (SNOBFIT). Significant improvements in the quality of solutions obtained under a 2500 function evaluation limit are observed for a large fraction of the test problems.

3 - Multi-Objective Two-Stage Stochastic Programming with Probabilistic Branch and Bound and Monte-Carlo Simulation

Hao Huang, Assistant Professor, Yuan Ze University, Taoyuan, Taiwan, haohuang@saturn.yzu.edu.tw

The main objective is to develop a multiple objective algorithm for two-stage resource allocation problems with statistical distribution uncertainty, simultaneously considering cost and risk assessment, by combining simulation optimization, Monte-Carlo simulation and mixed integer linear programming techniques. Specifically, a constrained version of Multiple Objective Probabilistic Branch and Bound with mixed-integer variables is introduced and applied to the first stage search, where the evaluation of second stage is performed with Monte-Carlo simulation.

4 - Autotune: A Derivative-free Optimization Framework for Hyperparameter Tuning

Yan Xu, SAS Institute, Inc., 1075 Upchurch Farm Lane, Cary, NC, 27519, United States, Yan.Xu@sas.com

Machine learning applications often require hyperparameter tuning. The hyperparameters usually drive both the efficiency of the model training process and the resulting model quality. For hyperparameter tuning, machine learning algorithms are complex black-boxes. This creates a class of challenging optimization problems, whose objective functions tend to be nonsmooth, discontinuous, unpredictably varying in computational expense. We present an automated parallel derivative-free optimization framework called Autotune, which combines a few specialized sampling and search methods that are very effective in tuning machine learning models despite these challenges.

5 - Efficiency of the Adaptive Sampling Trust-Region Optimization Derivative-Free (ASTRO-DF)

Sara Shashaani, North Carolina State University, 1221 Island Dr Apt 104, Raleigh, NC, 48105, United States, sshasha2@ncsu.edu, Raghu Pasupathy

ASTRO-DF is a class of adaptive sampling algorithms for solving simulation optimization problems that are derivative-free in the sense that they do not rely on direct observations of the function derivatives. The salient feature is adapting the computation effort to the algorithm trajectory to ensure efficiency. ASTRO-DF has been demonstrated to generate iterates that globally converge to a first-order critical point with probability one. We now identify the time complexity in two aspects: iterations and total work. We compare these complexities to those obtained from methods that use traditional random or fixed sampling rules.

■ TD41

CC- Room 610

Optimization Problems in Social Networks

Sponsored: Optimization/Network Optimization

Sponsored Session

Chair: Chrysafis Vogiatzis, North Carolina A&T State University, Greensboro, NC, 27411, United States

1 - On Polyhedra of Two Influence Maximization Problems in Social Networks

Cheng-Lung Chen, University of Central Florida, Orlando, FL, 32816, United States, chenglung@knights.ucf.edu, Vladimir Boginski, Qipeng Phil Zheng, Eduardo Pasiliao

Influence maximization problem in social networks has attracted more attention recently because of the rise of online social media platforms. Various studies have been focused on the improvement of approximation algorithm to find the optimal seed location so as to maximize total number of activated nodes. In this study, we investigate the polyhedral structure of the maximum active set formulation and its extension. We derive valid inequalities for both single and dual bound threshold on nodes and demonstrate the validity and strength of the proposed inequalities.

2 - Identifying Outlier Groups Using Combinatorial Optimization

Chrysafis Vogiatzis, North Carolina A&T State University, Greensboro, NC, 27411, United States, cvogiatzis@ncat.edu

In this talk, we present a variant of the graph bipartitioning problem, in which structural requirements are imposed. In addition to the homogeneity criterion of traditional graph bipartitioning, we also impose that one of the subgraphs satisfies a predefined structural property, i.e., the subgraph induces a given motif. This extension has applications in identifying fringe, outlier groups in online social networks. We derive the complexity of the problems, provide mathematical formulations for the problem, and present techniques to solve them exactly and heuristically. We conclude the talk with our computational results in both real-life and randomly generated networks.

3 - Presenter

Sean Suehr, North Carolina Agricultural and Technical State University, Greensboro, NC, 27411, United States, ssuehr@aggies.ncat.edu, Chrysafis Vogiatzis

Criminal networks are complex due to the limited and imperfect data available. In addition, entities participating in a criminal network tend to misrepresent themselves to entities outside the network. In this talk, we propose formulations to identify groups of entities that are prone to misrepresent themselves by enforcing a minimum distance between different neighbors of the group. We use newly developed formulations for k-clubs and we also extend the problem to other clique relaxations such as k-plexes and k-cores. We also propose valid inequalities and compare their performance to commercial solvers. Finally, we present computational results on a series of real-life and synthetic networks.

■ TD42

CC- Room 611

Modeling and Optimizing the Resilience of Networked Systems

Sponsored: Optimization/Network Optimization

Sponsored Session

Chair: Andres David Gonzalez, University of Oklahoma, Norman, OK, 73019, United States

Co-Chair: Camilo H Gomez, Universidad de los Andes, Bogota, Colombia

1 - Community Resilience Planning Decision Support via a Two-stage Stochastic Programming Model Integrating Critical Path Method and Flow Based Modeling

Kenneth W. Harrison, NIST, Gaithersburg, MD, United States, kenneth.harrison@nist.gov

NIST's Community Resilience program provides guidance for reducing hazard impacts — 2017 Hurricanes alone were estimated to cost $265 billion (FEMA) and displaced many. NIST's ARC model, a two-stage stochastic integer linear programming model, aids in the identification of effective mitigation actions (1st stage) while recognizing the costs and other challenges of recovery (2nd stage). Here, the recovery modeling is described, which includes critical path method-like calculations for a flow-based network that captures complex interdependencies among the involved physical (e.g., infrastructure) and social systems (e.g., housing). Results from a flood-based case study are presented.

2 - Auction-based Resource Allocation in Decentralized Decision Making for Interdependent Networks

Hesam Talebiyan, PhD Student, Rice University, Houston, TX, United States, Hesam.talebiyan@rice.edu, Leonardo Duenas-Osorio

The desired performance of decentralized decision makers is highly influenced by the number of available resources, and in turn, the mechanism used to allocate resources among them. In this talk, we propose that decision makers may engage in an "auction" to bid for resources and capture field-observed post-disaster decision processes. We explore different auction types and bidders' valuations, and compare them regarding computational burden and the ability to approach optimal resource allocations. We apply our approach to idealistic and real-world interdependent networks, and show that first- and second- price auctions significantly reduces the sub-optimality of decentralized plans.

3 - Modeling Infrastructure Operation Through Public-private-Partnerships - An Optimization-based Approach Combining Technical and Institutional Aspects

Camilo Gomez, Universidad de los Andes, Bogota, Colombia, gomez.ch@uniandes.edu.co, Camilo Daza, Jorge-Mario Lozano, Diego Castiblanco, Andres David Gonzalez

The operation and management of critical infrastructure systems depend on intensive logistical planning as well as on the institutional and regulatory context. Public-Private-Partnerships (PPPs) are a compelling means to carry out infrastructure projects. However, PPPs are prone to the 'agency problem', which states that one party (i.e., the private one) does not necessarily act in the best interest of the other (i.e., the public one). We propose a Mixed Integer Programming model to understand and address potential conflicts of interest in PPPs in the context of infrastructure maintenance problems (e.g., a contractor failing to comply with safety requirements in order to increase profits).

4 - Optimizing Supply Chain Network Restoration with Fair Distribution

Andres David Gonzalez, University of Oklahoma, Norman, OK, 73019, United States, Mastoor Abushaega

Supply chain networks are constantly under hazards associated with natural disasters and targetted attacks. Thus, being able to restore then quickly is imperative. In this paper, we propose a mathematical model that focuses on minimizing the unmet demands and restoration costs associated with a supply chain network, while guaranteeing that the distribution of commodities is done fairly. We show that by enforcing the fair distribution of commodities, the service levels are kept at high levels across the supply chain network.

5 - Network Resilience: How Firms Can Survive Economic Shocks

Toby Li, Texas A&M University, College Station, TX, United States, Taoufik Zormati, Andres David Gonzalez

Economic shocks cause businesses to fail, which can further exacerbate the resulting subsequent industry downturns. We ask whether a firm can strategically structure its network of partners - specifically the types of partners and the relationships with those partners - to make it more or less resilient to these economic shocks. We introduce this idea of "corporate network resilience" and offer unique features common for firms successfully building such a network. Our context is drillers and their network of client operators in the oil-gas industry during oil price shocks over the past three decades.

■ TD43

CC- Room 612

Computational Integer Programming

Sponsored: Computing

Sponsored Session

Chair: Ezgi Karabulut, Rensselaer Polytechnic Institute, Georgia Tech, Troy, NY, 12180-2406, United States

1 - Geometric Properties and Solution Methods for Inverse Mixed Integer Optimization

Ian Yihang Zhu, University of Toronto, 5 King's College Road, Toronto, ON, M5S3G8, Canada, i.zhu@mail.utoronto.ca, Merve Bodur, Timothy Chan

Inverse optimization (IO) broadly defines the set of problems in which we use a set of solutions of a "forward" optimization problem to infer unknown parameters of the forward problem. In this talk, we focus on the inverse mixed integer optimization problem, which denotes the problem of inferring the objective function of a mixed integer programming problem by observing a solution to that problem. We present new insights into the geometric properties of these problems, and propose a set of enhancements to be used in conjunction with existing cutting-plane approaches that lead to substantial computational gains in MIPLIB benchmark instances.

2 - A Simulated Annealing Based Approach for the Directed Steiner Tree Problem

Matias Siebert, Georgia Tech, Atlanta, GA, United States, msiebert6@gatech.edu

A new approach for the directed Steiner tree problem has been recently proposed, which consists in solving a set of integer programs (IP). Each IP finds an optimal directed Steiner tree with a specific structure, and can be solved in polynomial time. But, the number of IPs to solve grows exponentially with the number of terminal nodes. We propose a Simulated Annealing based approach to address the latter issue. We present an algorithm to solve each subproblem efficiently, and a complete characterization of the neighborhood of each tree structure.

3 - On the Depth of Cutting Planes

Laurent Poirrier, University of Waterloo, Combinatorics and Optimization, Waterloo, ON, N2L 3G1, Canada, James Yu

Cut selection has become a major question in Integer Programming. We can now compute many cuts, but we cannot add them all, and it is not clear how we should be selecting the "best" ones. To that end, we propose a concept of "depth" that applies to individual cutting planes as well as entire families. It has a natural definition and nice properties that make it easy to work with theoretically, and we argue that it is a good proxy for the practical strength of cuts. In particular, we give parametric upper bounds on the depth of two prominent types of cutting planes, which nicely line up with computational observations. Finally, we show how to efficiently compute the depth of an individual cut.

4 - Online Optimization for Ride-sharing

Ezgi Karabulut, Rensselaer Polytechnic Institute, Troy, NY, 12180-2406, United States, karabe@rpi.edu, Jennifer A. Pazour

A ride-sharing problem can be formulated as a bilevel optimization problem, where the leader is the platform, maximizing the platform's utility, and the followers are the set of drivers, maximizing their individual utilities. This problem can also be interpreted as an online optimization problem, where the ride-sharing problem needs to be solved repetitively for multiple iterations with changing data at every iteration, and where the followers' data is not directly accessible by the leader. Our goal is to continuously learn the followers' information throughout the iterations to improve the performance of the leader's bilevel optimization problem.

■ TD44

CC- Room 613

Computational Security Games and Applications

Sponsored: Computing

Sponsored Session

Chair: Wei Wang, University of Pittsburgh, Pittsburgh, PA, United States

1 - Quantifying a Game-theoretic Model of Pre-disaster Relocation from Two Coastal Cities

Yuqun Zhou, University of Wisconsin, Dept of Ind Eng Mechanical Eng Bldg, Madison, WI, 53706, United States, yzhou364@wisc.edu

In the face of sea-level rise, encouraging pre-flood retreat can be an effective way to reduce disaster damage, especially for vulnerable coastal cities. We apply our previous game-theoretic model to major U.S. coastal cities, using realistic estimates of future sea-level rise, realistic housing prices, and realistic government and resident discount rates. Results make it possible to assess the efficacy of "nudge" policies (i.e., government incentives encouraging voluntary relocation) as a function of flood probability, house elevation, property value, and resident/government discount rates.

2 - Interdependent Water & Electricity Distribution in the Virgin Islands

Daniel A. Eisenberg, Research Assistant Professor, Naval Postgraduate School, 1 University Circle, Monterey, CA, 93943, United States, daniel.eisenberg@nps.edu

In September 2017, Hurricanes Irma and Maria made landfall in the US Virgin Islands (USVI) Territory causing significant damage to local infrastructure. Since this event, recovery efforts for water and power infrastructure on St. Croix have been hampered by interdependent losses across both systems. This work presents interdependent operator models for water and electricity infrastructure systems and identifies operations and system designs that improve their resilience. Specifically, we develop a simulation optimization that uses couples the both systems models together and locates decision variable values that maximize (best-case) or minimize (worst-case) performance.

3 - A New Defender-attacker-defender Model for System Protection

Wei Wang, University of Pittsburgh, Pittsburgh, PA, 15261, United States, w.wei@pitt.edu, Bo Zeng

Traditional defender-attacker-defender (DAD) game, seeking optimal defense or hardening strategies against physical attacks, is widely used in many infrastructure protection applications. However, it ignores the possible restrictions that can be placed by the defender in the decision-making process of the attacker. In this study, we formulate a new DAD game model to fully utilize this advantage of the defender. Novel reformulation and decomposition techniques are developed for solving the resulting complex problem. Computational experiments on typical power grids will be presented to illustrate the advantages of our new model and the solution method.

4 - Strategic Interdiction of Network Flows

Mathieu Dahan, Georgia Institute of Technology, Atlanta, GA, United States, mdahan@mit.edu, Saurabh Amin, Patrick Jaillet

In this talk, we consider a generic network security game on flow networks. In this game, a routing entity sends its flow through the network while facing transportation costs, and an interdictor simultaneously interdicts multiple edges while facing interdiction costs. By proving the existence of a probability distribution on a partially ordered set that satisfies a set of constraints, we show that the equilibrium properties of the game can be described using primal and dual solutions of a minimum-cost circulation problem. Our analysis provides a new characterization of the critical network components in strategic flow interdiction problems.

■ TD45

CC- Room 614

Methods for Large Scale, Nonlinear and Stochastic Optimization- II

Sponsored: Optimization/Nonlinear Programming

Sponsored Session

Chair: Albert Berahas

1 - Analysis of the BFGS Method with Errors

Yuchen Xie, Northwestern University, Evanston, IL, 60201, United States, ycxie@u.northwestern.edu, Richard Byrd, Jorge Nocedal

The classical theory for BFGS method assumes that the function and gradients employed at each iteration are exact. In this study, we consider the case when there are (bounded) errors in the function and gradients computations, and establish conditions under which a slight modification of the BFGS algorithm with the standard Armijo-Wolfe line search converges to a neighborhood of the solution that is determined by the size of the errors. We present both theoretical analyses and numerical results illustrating the performance of the new BFGS method in the presence of noise.

2 - Limited-Memory BFGS with Displacement Aggregation

Baoyu Zhou, Lehigh University, Bethlehem, PA, United States, baoyu.zhou@lehigh.edu, Albert S. Berahas, Frank E. Curtis

We present a displacement aggregation strategy for the curvature pairs stored in a limited-memory BFGS method such that the resulting (inverse) Hessian approximations are equal to those derived from a full-memory BFGS method. Using said strategy, an algorithm employing the limited-memory method can achieve the same convergence properties as when full-memory Hessian approximations are employed. We illustrate the performance of an LBFGS algorithm that employs the aggregation strategy.

3 - Behavior of L-BFGS on Nonsmooth Problems in Theory and in Practice

Azam Asl, NYU, 251 Mercer st., New York, NY, 10012, United States, Michael Overton

When applied to minimize nonsmooth functions, the “full” BFGS method works remarkably well, typically converging linearly to Clarke stationary values, with no counterexamples to this behavior known in the convex case, though its theoretical behavior is not yet well understood. In contrast, limited-memory BFGS may converge to non-stationary values, even on a simple convex function, but this seems to be rare. We summarize our experience with L-BFGS in both theory and practice.

4 - A Log-barrier Newton-CG Method for Bound Constrained Optimization with Complexity Guarantees

Michael O’Neill, University of Wisconsin-Madison, Madison, WI, United States, mjoneill2@wisc.edu, Stephen J. Wright

We describe an algorithm based on a logarithmic barrier function, Newton’s method, and linear conjugate gradients, that obtains an approximate minimizer of a smooth function over the nonnegative orthant. We develop a bound on the complexity of the approach, stated in terms of the required accuracy and the cost of a single gradient evaluation of the objective function and/or a matrix-vector multiplication involving the Hessian of the objective. The approach can be implemented without explicit calculation or storage of the Hessian.

■ TD46

CC- Room 615

Transportation Network Resilience and Planning for Emergency Response

Sponsored: Transportation Science & Logistics/Intelligent Transportation Systems (ITS)

Sponsored Session

Chair: Nasrin Mohabbati Kalejahi, Auburn University, Auburn, AL, 36832, United States

1 - A Data-driven Resilience-based Approach for understanding the Operation of Transportation System

Farnaz Khaghani, Virginia tech, Blacksburg, VA, United States, farnazk@vt.edu

Traffic congestion has negative impacts on the general operation of urban communities. We propose using the concept of resilience, which usually has been used for extreme events and disturbance to the transportation system, for high-probability low impact events to quantify and assess traffic congestion and study the performance behavior of roadways. We determine the potential causes and drivers of the bottlenecks and look at the infrastructure options to improve the performance of the system through a data-driven multi-dimensional approach. Knowing the potential causes can lead to automotive and more efficient mitigation strategies to move towards sustainable and resilient mobility.

2 - Robust Optimization Model for Hazardous Materials Closed-loop Supply Chain Network Design with Locating Emergency Response Teams

Nasrin Mohabbati Kalejahi, Assistant Professor, California State University, San Bernardino, CA, United States, nasrin@auburn.edu, Alexander Vinel

In this study, we investigated the hazmat closed-loop supply chain network design problem and proposed a bi-objective stochastic robust mathematical formulation with the aim of minimizing the strategic, tactical and operational costs as well as the risk exposure on the road network. The proposed model provides a set of Pareto optimal solutions for locating the hazmat facilities such as production, distribution, collection, recovery and disposal centers, their corresponding capacities, the quantity of shipments across the network, and hazmat route planning. The emergency response team location decisions are made simultaneously with forward and reverse logistics design.

3 - Cyber-vulnerability Analysis for Connected Vehicle Based Traffic Signal Control Systems

Shihong Huang, University of Michigan, Ann Arbor, MI, United States, edhuang@umich.edu, Wai Wong, Yiheng Feng, Alfred Chen, Morley Mao, Henry Liu

Connected vehicle (CV) technology has great potentials in improving traffic signal control systems (TSCSs). On the other hand, the connectivity might open a new door for cyber attacks, if the vulnerabilities of the control systems can be identified and utilized by attackers. In order to effectively defend CV-TSCSs against cyber attacks, vulnerability analysis is the premise step. In this study, we propose a generic analysis approach for identifying the cyber-vulnerabilities of CV-TSCSs. A surrogate model is used to learn signal control logic and a feature selection method is applied to identify vulnerable traffic features. A comprehensive case study shows that the proposed approach is effective.

4 - Using Connected Vehicle Technology to Improve Emergency Response Vehicle Travel in an Urban Transportation Network

Thidapat Chantem, Virginia Tech, Blacksburg, VA, United States, Gaby Joe Hannoun, Pamela Murray-Tuite, Kevin Heaslip

A system using the connected vehicle technology is proposed to assist an emergency response vehicle’s (ERV) travel. The core of the system is an integer linear program that generates, as the ERV is travelling towards its destination, the optimal ERV intra-link movement as well as instruction messages for downstream vehicles, requesting them to stop at specific locations they can reach comfortably. The system is adapted to urban transportation networks with signalized intersections and with partial market penetrations of connected vehicles. The system reduces the ERV’s travel time and vehicular interactions while limiting the effect on downstream traffic.

5 - Ambulance Location and Relocation Problem for Nagoya in Japan

Keisuke Inakawa, Doctor of Business Administration, Akita Prefectural University, Akita, Japan, inakawa@akita-pu.ac.jp

Recently, the number of calls for ambulances tends to increase in Japan, and the mean response time is also increasing. In these contexts, Nagoya City is considering a plan for adding two more ambulances. In this research, we decide the optimal locations of additional two ambulances, and we evaluate the effect of additional two ambulances by the mean response time which is computed by a Markov chains simulation model. In addition, the relocation plan is also solved by the simple Median problem, and we compare these ambulance locations by the mean response time.

■ TD47

CC- Room 616

Best Dissertation Award Session

Sponsored: Transportation Science & Logistics

Sponsored Session

Chair: Sandra D Eksioglu, Clemson University, Department of Industrial Engineering, Clemson, SC, 29634, United States

1 - The Edge of Large-Scale Optimization in Transportation and Machine Learning

Sebastien Martin, PhD, Massachusetts Institute of Technology, Cambridge, MA, 02139, United States

Please check the mobile app for this abstract.

2 - Robust Optimization of Vehicle Routing Problems under Uncertainty

Anirudh Subramanyam, Argonne National Laboratory, 9700 S. Cass Ave, Lemont, IL, 60439, United States

Abstract not yet available.

■ TD48

CC- Room 617

TSP, VRP, and Related Applications

Sponsored: Transportation Science & Logistics/Freight Transportation & Logistics

Sponsored Session

Chair: Vikrant Vaze, Dartmouth College, Hanover, NH

1 - An Order-first Split-second Approach to an Application of the Multiple Traveling Salesman Problem

Norbert Trautmann, University of Bern, FM Quantitative Methoden, Bern, 3012, Switzerland, norbert.trautmann@pqm.unibe.ch, Chantal Schöni, Philipp Baumann

We consider a service operations management problem of a real-estate valuation company; it consists in routing on-site visits of properties such that the total operating costs are minimized subject to various constraints including a lower bound on the number of visits in each route. We propose an order-first split-second approach which first, applies the Concorde solver to determine an optimal TSP solution for the set of all visits, and second, splits this TSP solution into sequences of visits by solving a BLP. Our results for various-sized instances indicate that our approach requires less CPU time than a recent matheuristic to devise feasible solutions with comparable total costs.

2 - Generalizing the Covering Path Problem on a Grid

Liwei Zeng, Northwestern University, Evanston, IL, United States, Karen Smilowitz, Sunil Chopra

This paper generalizes the covering path problem on a grid which finds the cost-minimizing path connecting a subset of points such that each point is within a predetermined distance of a point from the chosen subset. We leverage the geometric properties of the grid to introduce simple construction techniques to provide path cost bounds within a constant factor.

3 - Consistent Routing with Simultaneous Pickups and Deliveries

Mohsen Emadikhiav, University of Connecticut, Storrs, CT, 06066, United States, Mohsen.emadikhiav@uconn.edu, David Bergman, Robert Day

We consider a new class of vehicle-routing problems with simultaneous pickups and deliveries where consistency of site visits is desired. Our problem is motivated by the operations of an instrument-calibration company, where items need to be transferred among different laboratories around the country, with multi-day processing at each facility. We develop a mixed-integer programming model and propose branch-and-check and branch-and-price implementations, with an analysis of the instance characteristics for which each of these algorithms outperforms the other.

4 - Strategic Learning in Routing Games with Private Information

Manxi Wu, Massachusetts Institute of Technology, Cambridge, MA, United States, manxiwu@mit.edu, Saurabh Amin

We study a learning dynamics in which traveler populations repeatedly route on a transportation network with an uncertain state. In each stage, travelers choose routes according to Bayesian Wardrop equilibrium based on the initially acquired private information, and the repeatedly updated public belief of the state. An information system updates the belief based on noisy stage outcomes according to Bayes' rule. We show that the belief and edge load converge almost surely to a rest point, where travelers have no incentive to deviate and the estimated costs on taken edges are accurate. We highlight some conditions under which the learning is complete in that travelers route as if they know the true state.

5 - Column Selection by Machine Learning in Exact Branch-and-price Algorithms

Mouad Morabit, Polytechnique Montreal & Gerad, Montreal, QC, Canada, mouad.morabit@gerad.ca, Guy Desaulniers, Andrea Lodi

Column generation (CG) is a well-known method for solving large-scale linear problems. In this presentation, we propose to integrate a machine learning technique in the context of CG to reduce computation time. More precisely, a classification algorithm is proposed to select promising columns at each CG iteration when solving a problem that is subject to degeneracy in the master problem. Applications to the vehicle and crew scheduling problem and the vehicle routing problem with time windows will be presented.

■ TD49

CC- Room 618

UAV Enabling Technologies via Operations Research Methods

Sponsored: Transportation Science & Logistics/Urban Transportation

Sponsored Session

Chair: Sung Hoon Chung, Binghamton University, Binghamton, NY, 13902, United States

Co-Chair: Jinkun Lee, East Carolina University, Greenville, NC, 27858-4353, United States

1 - Simulation of Drone Truck Combined Operation

Jinkun Lee, East Carolina University, Engineering Dept., 1000 E. 5th St. East Carolina University, Greenville, NC, 27858-4353, United States, leejin18@ecu.edu, Sung Hoon Chung

We propose an improved drone-truck combined operation routing solution by adopting the concept of drone operation sortie and introducing a pseudo node to minimize waiting time either from drone and truck. However, an optimal solution found need to be adjusted for real world situation since there exist several constraints such as truck's extended stay time at nodes, drone's takeoff/landing time, and so on. We consider such minor but non trivial conditions by using a simulation model and compare the discrepancies between an optimal solution and the simulation result. By doing this, we identify the impact of several assumptions used at the pseudo node algorithm to simplify the problem statement.

2 - Continuous Border Surveillance Using Drones with a Dynamic Wireless Charging System

Navid Ahmadian, University of Houston, UH, Houston, TX, United States, nahmadian@uh.edu, Gino J. Lim, Maryam Torabbeigi, Seon Jin Kim

We propose a continuous surveillance system using unmanned aerial vehicles (UAVs) for border patrol. To overcome a short flight duration due to battery limitations, a dynamic wireless charging system using electrification line (E-line) is used to increase the flight time. A Mixed Integer Programming (MIP) model is introduced to minimize the total length of E-line and number of drones to minimize total expenses. This model can control the maximum time gap between two consecutive visits to a particular location of the border based on the criticality of that location.

3 - Vehicle Routing Problem with Flexible Drones

Ilke Bakir, University of Groningen, Herestraat, Netherlands, i.bakir@rug.nl, Gizem Ozbaygin

We study the vehicle routing problem with flexible drones, where the drones can switch between vehicles. We demonstrate the performance improvements provided by this flexibility compared to the setting where the drones must come back to their original vehicle. We model this problem using a time-expanded network, and provide optimal solutions for benchmark problem instances. To solve large problem instances, we present a dynamic discretization discovery (DDD) algorithm, which iteratively refines the time-expanded network. We present an extensive computational study that demonstrates the benefits provided by using flexible drones and the solution performance of DDD in this problem setting.

4 - Combined Operations for Multiple Drones and Multiple Trucks

Sung Hoon Chung, Binghamton University, Binghamton, NY, 13902, United States, Bhawesh Sah

In this talk, we discuss how combined operations for multiple doses and multiple trucks can be managed using the proposed model. In addition, a new heuristic method based on the combination of genetic algorithm, simulated annealing, and greedy algorithm in conjunction with the insertion method is proposed to solve the problem.

5 - Airship-based Drone Delivery System: Quantitative Approach for Managerial and Operational Guidelines

Ho Young Jeong, Purdue University, West Lafayette, IN, 47906, United States, Seokcheon Lee

This study aims to investigate transportation possibility by cooperative utilization of airship and drones. The airship is a type of lighter-than-air aircraft that works as a station for drones, and the drones work as a direct delivery mean to end customers. This collaborative delivery system selectively and synergistically exploits the strengths of the individual vehicles. The validity of the system is verified via a mathematical model on a realistic case study. Moreover, the quantitative analysis provides operational insight into the system and suggest managerial and operational guideline.

■ TD50

CC- Room 619

Transportation, Planning II

Contributed Session

Chair: Mohamad Kamal El Din Ahmad Hasan, Kuwait University, Department of Quantitative Methods & IS, CBA, Kuwait City, 13055, Kuwait

1 - Evaluating Curb Strategies to Mitigate the Impacts of Ridehailing Services on Traffic

Andisheh Ranjbari, University of Washington, Seattle, WA, United States, ranjbari@uw.edu, Anne V. Goodchild, Don MacKenzie, Jose Luis Machado, Giacomo Dalla Chiara

Increased ridehailing use leads to increased pick-up and drop-off activity. This may slow traffic or cause delays as vehicles increase curb use, conduct pick-up/drop-off activity in the travel lane, or slow to find and connect with passengers. How should cities respond to this change in an effort to keep travel lanes operating smoothly and efficiently? This research evaluates two strategies in Seattle, WA: 1) a curb allocation change from paid parking to passenger load zone, and 2) a geofencing approach, which restricts pick-up and drop-off activity to designated locations on a block. The results report the impacts on travel speeds, dwell times, curb use compliance, safety, and user satisfaction.

2 - Determining Urban Charging Infrastructure Requirement for Electric Ride Hailing Fleets

Zicheng Bi, Postdoctoral Appointee, Argonne National Laboratory, Lemont, IL, United States, zbi@anl.gov, Fei Xie, Yan Zhou, Zhenhong Lin

We propose a decision-making framework that estimates required charging infrastructure in an urban area to support electric ride-hailing operations based on specific travel demand. Without the requirement to conduct the actual network modeling, decisions are made based on probabilistic distributions of initial state of charge, geographic locations of destinations, lengths of passenger and deadheading trips, temporal arrival, and charging duration patterns, etc. This framework is used for estimating charging opportunity, market share of electric vehicles, and national energy consumption of light-duty vehicles.

3 - Developing a Sustainable Transport System under Electric and Autonomous Vehicles Dedicated Lane Deployment Scheme

Young Joun Ha, Purdue University, West Lafayette, IN, United States, ha55@purdue.edu, Mohammad Miralinaghi, Samuel Labi

While there is abundant research regarding AV-exclusive lane deployment schemes to minimize travel time, holistic considerations of sustainability are often ignored. This study presents a discrete network design problem to find an optimal AV-exclusive lane deployment scheme while considering three critical elements of sustainability: economic impact, environmental protection, and social equity. The problem is constructed as a bi-level optimization, where the upper-level captures the planner's goals to minimize travel cost and emissions while preserving equity; and the lower-level captures the behavior of travelers who seek to minimize their travel costs by choosing vehicle and route.

4 - The Morning Commute Problem with Braking and Overtaking Behaviors under Single Step Tolling

Da Xu, University of Windsor, Windsor, ON, Canada, Xiaolei Guo, Kevin W. Li

We develop a new bottleneck single step tolling model for the morning commute problem. This model considers that some commuters brake their cars to postpone their arrival at the bottleneck to avoid paying the toll, while others can overtake them to pay the toll. The overtaking cost is proportional to the number of braking commuters. Two classic single step tolling models, the separate waiting lane model and the braking model, are special cases of this new model. We seek to minimize the total system cost and find that the optimal tolling scheme depends on the unit overtaking cost.

5 - Service Network Design for Same-Day Delivery with Hub Capacity Constraints

Haotian Wu, Georgia Institute of Technology, Atlanta, GA, United States, hwu393@gatech.edu, Ian Hodara Herszterg, Martin W.P. Savelsbergh

We study a service network design problem for a same-day delivery system where the carrier must ensure that hub capacities, i.e., maximum number of vehicles that can be loaded and unloaded at the same time, are respected. We formulate the problem using an integer programming (IP) model on a time-expanded network, and develop two heuristic approaches (1) IP-based heuristic and (2) metaheuristic that solve the problem in di erent ways. We test and compare our approaches on three real-world instances with di erent geography scenarios, sizes, and planning horizon lengths from a leading Chinese package express company, and demonstrate the efficiency of proposed technologies.

6 - Supernetwork Representation Formulation of a Multiclass Simultaneous Transportation Equilibrium Model as a Fixed Demand User Equilibrium Problem

Mohamad Kamal El Din A. Hasan, Professor of Operations & Supply Chain Management, Kuwait University, Kuwait City, Kuwait, mkamal@cba.edu.kw, Mohammad Saoud, Raed Al-Husain

The Multiclass Simultaneous Transportation Equilibrium Model (MSTEM) explicitly distinguishes between different user classes in terms of socio-economic attributes, trip purpose, pure and combined transportation modes, as well as departure time, all interacting over a physically unique multimodal network. It enhance behaviorally the prediction process, however, the development of this concept of multiple classes increases the mathematical complexity of travel forecasting models. In this research, we reduce this mathematical complexity by using the Supernetwork Representation Formulation of the (MSTEM) as a Fixed Demand User Equilibrium (FDUE) Problem.

■ TD51

CC- Room 620

Joint Session AAS/TSL Air/Practice Curated: aas Operations and Efficiency

Sponsored: Aviation Applications

Sponsored Session

Chair: Susan Hotle, Virginia Tech, Blacksburg, VA, 24061, United States

1 - Analyzing Airport Surface Performance Using ASDX-X Surveillance Information

Susan Hotle, Virginia Tech, 200 Patton Hall, Blacksburg, VA, 24061, United States, shotle3@vt.edu

Currently, airport surface performance and delay is calculated by the FAA using a regression method where flights in the ASPM database are benchmarked based on the season of operation, airline, airport, and calendar year. The method utilizes airline-reported Gate-Out, Wheels-Off, Wheels-On, Gate-In times. The purpose of this study is to alternatively use ASDE-X surveillance information to evaluate the taxi-out and taxi-in operational performance at six large U.S. airports for the month of July 2015. Results show the benefits of using surveillance information, including spatial analysis which allows for identification of taxiway locations that were the most susceptible to delays.

2 - Delay Propagation and Causal Factors

Stephanie Atallah, Virginia Tech, Blacksburg, VA, United States, asteph93@vt.edu

Flight delay is an important metric to the FAA, providing an indicator of the NAS's operational performance by supporting ICAO's Key Performance Indicators (e.g. En-Route delay and Airport/Terminal delay). Since a single flight delay can have a chain effect in future flights operated by the same aircraft, it is important to link the propagated delay to the original source as well as identify areas in the system that promote schedule recovery. This presentation uses ASPM, OPSNET, and ASQP data to: 1) develop delay propagation performance metrics that incorporate the causal reasons for the original delay and 2) better understand factors that affect schedule recovery after the original delay occurred.

3 - Demand Forecasting and ULD Packing for the Air Cargo Industry

Bruno F. Santos, TU Delft, Kluyverweg 1, Faculty of Aerospace Engineering, Delft, 2629 HS, Netherlands, b.f.santos@tudelft.nl

We present a framework to assist air cargo revenue management. The main driver behind this research is that the dimensions of cargo are usually not known at the time of booking. The framework is composed of a forecast and an optimization block. The forecast block consists of a random forest method to predict bookings dimensions. The optimization block (i) recomputes the cargo loading strategy if the new booking is accepted, or (ii) declines the incoming request. Preliminary results are comparable, in terms of loaded cargo volume, with real cases. Booking origin was determined to be the most relevant feature when predicting piece dimensions, and an average prediction error of 9.89 cm was achieved.

4 - The Crew Pairing Problem with Language Constraints

Frederic Quesnel, GERAD, Montreal, QC, H2M 2H8, Canada, frederic.quesnel@gerad.ca

Air crew rostering is usually performed according to a two-step sequential procedure: crew pairing (CPP) and crew rostering (CRP). This talk focuses on language constraints, imposing requirements on the language skills of the crew composition of some legs, and usually included only in the CRP. One shortcoming of the sequential method is that the pairings returned by the CPP may be incompatible with the language skills of the crews. We propose a variant of the CPP, called CPP with language constraints, that includes language constraints limiting the amount of work that can be performed in any language. We present results highlighting the performance of the method on several large-scale instances.

■ TD52

CC- Skagit 1

Dynamic Algorithms for Revenue Management in Online Markets

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Shreyas Sekar, Harvard University, Cambridge, MA, 02138, United States

1 - Learning to Rank an Assortment of Products

Shreyas Sekar, Harvard University, Cambridge, MA, 02138, United States, Kris Johnson Ferreira, Sunanda Parthasarathy

We consider the product ranking challenge that online retailers face when their customers typically behave as window shoppers and have limited attention spans. We present a class of online learning-then-earning algorithms that prescribe a ranking to each customer, learning from preceding customers' clickstream data-our algorithms balance popularity with diversity. Finally, we partner with Wayfair, an online retailer, to estimate the impact of our algorithm in practice via simulations using actual clickstream data, and we find that our algorithm yields a significant increase (5-30%) in the number of customers that engage with the site.

2 - Personalized Dynamic Pricing with Machine Learning

N. Bora Keskin, Duke University, Fuqua School of Business, Durham, NC, 27708-0120, United States, bora.keskin@duke.edu, Gah-Yi Ban

Motivated by online retail applications, we consider a seller who offers personalized prices to individual customers. The seller initially does not know the impact of individual customer characteristics on demand, but can learn about this relationship via sales observations. We construct and analyze near-optimal policies that balance the learn-and-earn tradeoff in this setting.

3 - Menu Costs and the Bullwhip Effect: Supply Chain Implications of Dynamic Pricing

Ioannis Stamatopoulos, University of Texas at Austin, McCombs School of Business, Austin, TX, 78705, United States, yannis.stamos@mccombs.utexas.edu, Robert Louis Bray

We study the supply chain implications of dynamic pricing. Specifically, we estimate how reducing menu costs — the operational burden of adjusting prices — would affect supply chain stability.

4 - Sealed-bid Procurement Auction with a Conditional Right of First Refusal

Adithya Patil, Indian School of Business, Hyderabad, India, Adithya_Patil@isb.edu, Milind Sohoni, Kalyan Talluri

We examine equilibrium bidding behavior, auctioneer payment, and efficiency in a two-player sealed-bid procurement auction where a preferred player (Player 1) is granted a right of first refusal if his bid is within a certain percentage of the non-preferred player's (Player 2) bid.

■ TD53

CC- Skagit 2

Machine Learning for Revenue Management

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Xi Chen, New York University, New York, NY, 10012, United States

1 - Dynamic Assortment Optimization in The Presence of Outlier Customers

Yining Wang, University of Florida, Gainesville, FL, United States, ynwang.yining@gmail.com

In this paper, we study the problem of dynamic assortment planning in the presence of outlier customers. In our setting, while most customers follow multinomial logit choice models, a fraction of the arriving customers will be "outliers" and might have arbitrary preferences of the items. We show how to handle such outlier customers by developing an "active elimination" type algorithm that sequentially remove items not preferred by non-outlier customers. Rigorous theoretical results are established to show the near-optimality of our proposed algorithm. An adaptive algorithm which does not require prior knowledge of outlier portions is also given.

2 - Context-based Dynamic Pricing with Online Clustering

Sentao Miao, University of Michigan Ann Arbor, Ann Arbor, MI, United States, semiao@umich.edu

We consider a context-based dynamic pricing problem of online products with low sales, which have insufficient data samples. To address this challenge, we propose pricing policies that concurrently perform clustering over products and set individual pricing decisions on the fly. We evaluate the algorithms using the regret, and the result shows that when product demand functions come from multiple clusters, our algorithms significantly outperform traditional single-product pricing policies. Our algorithms were implemented in a field study at Alibaba with 40 products for 30 consecutive days with an overall revenue increase of 10.14%.

3 - Sequential Batch Learning in Linear Contextual Contexts

Zhengyuan Zhou, Stanford University, Stanford, CA, 94305, United States, Yanjun Han, Zhengqing Zhou, Jose Blanchet, Peter W. Glynn, Yinyu Ye

We study sequential batch learning in linear contextual bandits where the decision maker is constrained to only perform learning in batches, rather than observing the reward feedback from each individual unit immediately as in the standard online learning setting. We consider two different settings: the contexts may either be chosen arbitrarily by an adversary, or independently drawn from some known probability distribution. In each setting, we provide an algorithm that achieves the minimax optimal regret bound.

4 - Truth and Regret in Online Scheduling/Pricing

Rad Niazadeh, Stanford University, Stanford, CA, 94305, United States, rad@cs.stanford.edu, Shuchi Chawla, Nikhil Devanur, Janardhan Kulkarni

We consider scheduling in a cloud service provider that has multiple units of a resource available over time. Selfish clients submit jobs with private parameters. The provider's goal is to implement a truthful online mechanism for scheduling these jobs so as to maximize economic efficiency. It is known that under stochastic jobs a single-parameter family of FIFO-pricing mechanisms is near-optimal. We show that given any such family, there exists a new online mechanism that in the worst case performs nearly as well as the best of the given mechanisms. Our mechanism is truthful whenever the mechanisms in the given family are truthful and prompt, and achieves optimal (within constant factors) regret.

■ TD54

CC- Skagit 3

Online Marketplaces and the Sharing Economy

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Maxime Cohen, NYU Stern, New York, NY, 10012, United States

Chair: Gad Allon, University of Pennsylvania, University of Pennsylvania, Philadelphia, PA, 19104, United States

1 - Spatial or Temporal Pooling Solves the Wild Goose Chase

Ming Hu, Rotman School of Management, University of Toronto, Rotman School of Management, 105 St. George Street, Toronto, ON, M5S 3E6, Canada, ming.hu@rotman.utoronto.ca

We identify when the so-called "wild goose chase" problem may arise in the sharing system of vehicles such as cars, bicycles, and scooters. We show how to solve this problem using operational tools such as spatial and temporal pooling.

2 - Ride-Hailing Platforms: Competition and Autonomous Vehicles

Terry Taylor, U.C. Berkeley Haas School of Business, Business School, Berkeley, CA, 119245, United States, taylor@haas.berkeley.edu, Auyon Siddiq

A central feature of ride-hailing platforms (e.g., Lyft and Uber) is that they simultaneously compete over a common pool of supply—namely, independent driver-workers—and a common pool of demand—namely, rider-consumers. Perhaps no development is perceived to have a larger potential for transforming the economics of ride-hailing platforms than the introduction of autonomous vehicles. This paper examines the implications of competition and access to autonomous vehicles technology for the management of ride-hailing platforms.

3 - The Impact of Behavioral and Economic Drivers on GIG Economy Workers

Park Sinchaisri, The Wharton School, Jon M. Huntsman Hall, Philadelphia, PA, 19104, United States, swich@wharton.upenn.edu, Gad Allon, Maxime Cohen

Gig economy firms benefit from labor flexibility by hiring independent self-scheduling workers but such flexibility poses a great challenge in planning and committing to a service capacity. In collaboration with a ride-hailing company, we study how on-demand workers make labor decisions: when to work and for how long. We are interested not only in improving the prediction of the number of active workers but also in understanding how to better recruit them. Careful econometric analysis of actual work decisions and responses to incentives, accounted for sample selection and endogeneity, has revealed behavioral insights that can inform better incentive design.

4 - Information Disclosure in Service Platforms: Optimizing for Supply

Wenchang Zhang, Robert H. Smith School of Business, Silver Spring, MD, 20904, United States, wzhang@rhsmtih.umd.edu, Kostas Bimpikis, Yiangos Papanastasiou

The use of information provision as an operational lever in two-sided platforms has received significant attention recently as a means of aligning consumer incentives with those of the platform. This paper analyzes the as-of-yet unexplored interaction between information provision and supply-side incentives. We develop a dynamic model where providers of ex ante unknown quality choose whether to join a service platform and, if so, set their price in response to the platform's commission rates and feedback information-provision policy.

■ TD55

CC- Skagit 4

Revenue Management with Choice, Learning and Optimization

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Ruxian Wang, Johns Hopkins University, Carey Business School, Kensington, MD, 20895, United States

1 - Display Ranking Optimization under Multinomial Logit Preferences

Ali Aouad, London Business School, London, NW64TG, United Kingdom, aaouad@london.edu, Danny Segev

Motivated by applications to online search and in-store merchandizing, we study a display optimization model in face of unit-buying customers, in a setting where the item rankings influence the likelihood that the customers consider the displayed alternatives. Under the widely-used Multinomial Logit choice model, we devise the first efficient algorithm that approximates the optimal ranking within any level of accuracy. We develop a notion of approximate subsets, which may be of broader interest in multiple-knapsack problems. Experiments on real and synthetic data sets demonstrate the value of the proposed display optimization approach.

2 - Consumer Choice and Market Expansion: Modeling, Optimization and Estimation

Ruxian Wang, Johns Hopkins University, Carey Business School, Washington DC, DC, 20895, United States, ruxian.wang@jhu.edu

Market size, measured by the number of people who are interested in products from the same category, may be highly influenced by assortment planning and pricing decisions. This effect is referred to as market expansion. In this paper, we incorporate the market expansion effects into consumer choice models and investigate various operations problems.

3 - Approximate Linear Programming for a Queueing Control Problem

Saied Samiedaluie, University of Alberta, Alberta School of Business, Edmonton, AB, T6G 2R6, Canada, Dan Zhang

We study a classical queueing control problem with multiple classes of customers. The queue is a loss system; i.e., arriving customers are rejected if all servers are busy. When a server is available, the decision is whether to admit an arriving customer and collect a lump-sum revenue. We model this problem as a continuous-time infinite-horizon dynamic program and propose approximate linear programming methods to solve the problem under three approximation architectures: affine, finite affine, and separable piecewise linear. We numerically investigate these approximation alternatives both in terms of the quality of the bounds and the policy performance.

4 - Reinforcement Learning under Drift

Ruihao Zhu, Massachusetts Institute of Technology, Cambridge, MA, 02139, United States, rzhu@mit.edu, Wang Chi Cheung, David Simchi-Levi

We study the problem of reinforcement learning under drift where both the reward functions and state transition distributions are allowed to evolve over time. For this problem, we propose learning algorithms that achieve state-of-the-art dynamic regret bounds. Our main contributions are: 1) A tuned Sliding Window Upper-Confidence bound for Reinforcement Learning algorithm armed with a crucial confidence widening technique, which attains provable dynamic regret bound against the optimal non-stationary policy. 2) The Bandit-over-Reinforcement Learning framework that further permits us to enjoy this dynamic regret bound in a parameter-free manner.

■ TD56

CC- Skagit 5

Marketing I

Contributed Session

Chair: Buqing Ma, University of Science and Technology of China, Champaign, IL, 61820, United States

1 - A Content Analysis of Nike's Partnership with Colin Kaepernick

Xin Wang, PhD, Stonehill College, Easton, MA, United States

This research studies public's reactions to Nike's partnership with Colin Kaepernick to be the face of the 30th anniversary of its JustDoIt campaign in September 2018. The content analysis reveals the major topics and extract the hidden semantics from the text. In addition, it explores the degree of a user's connections and help identify the most influential users. This research not only will provide insights on people's sentiments toward the Nike's partnership decision but also shed lights on how brands can understand and influence customers attitude toward marketing campaigns.

2 - Content Sharing Strategy under Consumer Multi-Purchase

Min Jiang, Shanghai University of Finance and Economics, Shanghai, China, jiangminabc@163.com

This paper studies homemade content's sharing strategy in video streaming markets. This paper explicitly models the consumer's multi-product purchase behavior, and examines a content distributor's homemade content's sharing strategy. We find that content distributor's homemade content's sharing strategy under multi-product purchase differs from that under single-product purchase. The focal content distributor chooses to share its new content with its rival distributor under single-product purchase but not to share under multi-product purchase. However, when the two content distributors are asymmetric, we find some different results.

3 - Signaling Quality through Positive Leadtime in Advance Selling

Teng Niu, School of Management, Xi'an Jiaotong University, Xi'an, China, ntancjh31@stu.xjtu.edu.cn, Qin Su

Advance selling is an important way for a seller to introduce new products. Considering consumers always face the quality uncertainty when they buy in advance period, we introduce a signaling mechanism in which the seller deliver a credible signal of product quality through positive leadtime in advance selling. Our results underscore the significance of positive leadtime and identify two implications for seller's policy in advance selling: (a) the seller's incentive to disclose the positive leadtime will diminish the consumer's uncertainty about product quality; (b) high-quality seller can differentiate with low-quality seller through positive leadtime with profits sacrifices sometimes.

4 - The Length of Product Line in Distribution Channels under Fairness Concern Prospect

Ying Zha, PhD Candidate, University of Science and Technology of China, Hefei, China, zhazhadz@mail.ustc.edu.cn, Jie Wu, Xiang Ji

This paper studies a manufacturer's optimal decision on extending its product line when the manufacturer or retailer takes their fairness concern into consideration in a decentralized channel. We find that fairness concern will reduce the motivation of the manufacturer to extend the product line, because fairness may lead to a manufacturer's profit reduce. And the manufacturer may use their wholesale price to achieve product line extensions under its fairness concern.

5 - A Machine Learning Approach for Predicting Shopping Trip Motivations Using Retail Transactional Data

Andres I. Musalem, Ing.Ind. U. de Chile, Complex Engineering Systems Inst, Santiago, 8370456, Chile, amusalem7@gmail.com, Luis Aburto, Jochen De Weerdt, Maria Óskarsdóttir, Richard Weber

We formulate a Hierarchical Bayesian Latent Dirichlet Allocation (LDA) model, to detect and predict shopping trip motivations of customers visiting a store selling products from multiple categories. For each motivation, customers are more likely to purchase only certain products. The model allows these motivations to depend on the shopping basket size and customer characteristics (e.g., demographics and past behavior). The model is tested using supermarket data for a panel of customers.

6 - Consumer Information Sharing in a Distribution Channel: Hindering or Facilitating?

Buqing Ma, University of Science and Technology of China, Hefei, China, mabuqing@illinois.edu, Guang Li

We study the optimal management strategy of an online retailer's consumer information sharing system and investigate the effect of the retailer's strategy on the manufacturer's quality decision in a distribution channel. Counterintuitively, we find the retailer would hinder consumer communication even when the customer's perceived quality is lower than the true product quality. Furthermore, the manufacturer can be better off by keeping constant product quality than making the optimal decision in every period with myopic consumers. Our results also show that surprisingly, deterring customers from knowing the true product quality may generate more consumer surplus.

■ TD57

CC- Yakima 1

Joint Session PSOR/Practice Curated: Applied Advances in the Field of Emergency Response I

Sponsored: Public Sector OR

Sponsored Session

Chair: Jordan Srour

Co-Chair: Pieter van den Berg, RSM, Rotterdam, 3062 PA, Netherlands

1 - Strategic Games Among Decentralized Emergency Services in Emerging Economies

Lavanya Marla, University of Illinois Urbana Champaign, Urbana, IL, United States, lavanyam@illinois.edu, Peter McGlaughlin, Jungeun Shin

In emerging economies, centralized 911-type EMS is in nascent stages, with decentralized EMSs established by hospitals serving as the default option. We study such strategic behavior by considering a simplified line-model setting. Providers choose service regions to maximize utilities. We model this as a non-cooperative game, and use a renewal-theoretic model for the endogeneity between the providers' decisions. We show that the providers' utility functions are unimodal, and admit a pure strategy Nash equilibrium. We also analyze the Price of Anarchy (PoA), and demonstrate that bargaining mechanisms such as coco-decomposition can reduce negative externalities due to competition.

2 - Effective Use of Call Prioritization in EMS Control Rooms to Maximize Available Resources

Jerry Overton, President, International Academies of Emergency Dispatch, Salt Lake City, UT, United States, Jerry.Overton@emergencydispatch.org

Internationally, the demand for out of hospital care is growing at an alarming rate. This increase is taxing the capacity of emergency response systems worldwide. The problem, however, is not from an increase in higher acuity patients, but from those calling to resolve lower acuity problems. A solution to ensure resource preservation and better resource allocation to meet the patients' needs is to prioritize the request for service at the time of call taking by Emergency Medical Dispatchers. This evidence-based talk will demonstrate how protocols for prioritization can identify call types and in turn control and allocate the appropriate resources to improve overall system response.

3 - FireScore, a Visualization Tool for Firefighter Planning

Robert van der Mei, CWI & Vu University, Amsterdam, Netherlands, Guido Legemaate

This is a framework that acts as a front-end for other components. It visualizes the system in which the emergency service provider operates. On an operational level it is a near real time visualization of incidents, vehicles, status, and expected coverage. Manipulating vehicle status forces a recalculation and visualization. A data broker extracts and provides data to power i.a. a relocation engine. An additional simulator is currently used for a project in which a reinforcement learning algorithm is tasked to learn how to optimally relocate fire trucks during major incidents. The basic functionality is intended to go live on the Amsterdam emergency dispatch center in June 2019.

4 - Does GPS Data Matter for Emergency Call Volume Prediction?

Jordan Srour, Lebanese American University, Adnan Kassar School of Business, P.O. Box 13-5053, Beirut, 1102 2801, Lebanon, jordan.srour@lau.edu.lb

Emergency call prediction schemes serve to give emergency responders information on appropriate staffing levels in terms of both time and location. These prediction schemes are largely based on aggregating past call data at various levels of granularity. If GPS data is available, then the appropriate aggregation level is in the hands of the forecaster; if only call-region data is available, then the decision space on the aggregation level for the forecast shrinks. In this research we compare the accuracy of several emergency prediction schemes on these two types of emergency call data - GPS location data and call location at a predetermined regional level.

■ TD58

CC- Yakima 2

Resilient Infrastructure and Community Networks

Sponsored: Public Sector OR

Sponsored Session

Chair: Yasser Almoghathawi, PhD, King Fahd University of Petroleum and Minerals, University of Oklahoma, Dhahran, 73019, Saudi Arabia

1 - A Project Management Perspective on Network Restoration Scheduling

Kash Barker, University of Oklahoma, Norman, OK, 73019, United States, Deniz Berfin Karakoc

A number of optimization formulations have been proposed to determine a restoration order and work crew schedule for recovering disrupted single and interdependent infrastructure networks. This work considers restoration from a project management perspective, (i) analyzing critical restoration tasks and (ii) estimating restoration project delays.

2 - Co2 Emissions Reduction by Identifying Optimal Level of Co-firing Biomass and Natural Gas in Coal-burning Power Plants

Ashkan Mirzaee, PhD Student, University of Missouri, Columbia, MO, 65201, United States, Ronald McGarvey, Francisco Aguilar

Biopower, the electricity generated from woody biomass, is considered as a carbon neutral and renewable source of energy that can be co-fired in power plants in order to cut carbon pollution. In this research, an optimization model is developed to identify the optimal amount of electricity to be generated from woody biomass, natural gas, and coal at a candidate set of US power plants. The MILP model minimizes the total cost of generating the required electricity projected to be demanded by the EIA through 2030, with environmental and spatially-explicit woody biomass availability constraints.

3 - Component Importance Measure for a Network of Interdependent Infrastructure and Industry Sectors

Scott N. Clayman, Pennsylvania State University-Great Valley, Malvern, PA, United States, snc163@psu.edu, Devendra P. Jaiswal, Mohamad Darayi

This work studies sector criticality in a larger system of interdependent infrastructure and industry sectors. A data-driven network analysis methodology is developed to group the industry sectors within the US in order to highlight strongly coupled groups, with a focus on the most important states which are in trade with Pennsylvania. Considering a multi-regional input-output representation of the coupling among the industry sectors, this work offers a broader perspective on network vulnerability analysis with a means to measure importance of network components.

4 - Post-disruption Community Structures Restoration for Enhancing Interdependent Infrastructure Network Resilience

Yasser Almoghathawi, King Fahd University of Petroleum & Minerals, Dhahran, 31261, Saudi Arabia, moghathawi@kfupm.edu.sa

Community structures exist in many infrastructure networks such as power, water, and gas networks. Such community structures are formed based on physical connections, or spatial features, among others. However, Infrastructure networks are becoming more interdependent to be functional which make them highly vulnerable to any disruption. This work addresses the restoration problem of community structures in a system of infrastructure networks that are physically interdependent. Hence, an optimization model is developed with the objective of enhancing the resilience of the system, which is demonstrated with a system of interdependent networks considering different disruption scenarios.

■ TD58a

CC- Chelan 1

2:00-2:45 AMPL / 2:45-3:30 Provalis Research

Vendor Tutorial

1 - Model-Based Optimization with AMPL: New Connections to Analytics Tools and Environments

Robert Fourer, AMPL Optimization Inc., Evanston, IL, 60201, United States

Built on the concept of model-based optimization, AMPL's intuitive algebraic modeling language and prototyping environment give you a fast start on prescriptive decision-making projects. AMPL then also helps you reach a successful conclusion, by providing connections to widely used analytics tools and environments. This presentation introduces and demonstrates a range of newly added and enhanced connections of general interest, including (1) expanded and enhanced interfaces to spreadsheet data, (2) access to solver callbacks, (3) building AMPL models in Jupyter notebooks, and (4) running AMPL as a flexible cloud service.

2 - An Insider's Look at Text Analytics: What Works, and What They Don't Tell You

Adam Bendriss Alami, Provalis Research, Montreal, QC, Canada

Text analytics provides real value to help shape and grow a business. That statement isn't up for analysis. Text analytics works but it doesn't necessarily work the same way for everyone. To make text analytics work for you, you need to know some of the pitfalls to avoid the pratfalls. We will show you techniques and methods you can deploy, what's behind them and what to watch out for.

■ TD59

CC- Chelan 2

Advancements in Spatial and Temporal Data Analytics - II

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Jian Liu, University of Arizona, Tucson, AZ, 85721, United States

Chair: Shyam Ranganathan, Virginia Polytechnic Institute and State University, Blacksburg, VA, 24061, United States

1 - A Semiparametric Integrated-spatial-temporal Mixed Effects Single Index Model

Inyoung Kim, Virginia Tech, Blacksburg, VA, United States, inyoungk@vt.edu

Environmental health studies are of often interest in human research to evaluate the relationship between mortality and temperature by incorporating spatial correlation and other weather variables. Since this relationship cannot be expressed by a parametric model, a nonparametric model is often used to estimate this relationship. A semiparametric integrated-spatial-temporal mixed effects single index model is proposed. It can detect subtle changes among spatial effects, covariates, and nonparametric function. It is useful when the spatial areas are located close to each other because the nonparametric function may not be separated from spatially correlated random effects.

2 - Graph-regularized Joint Tensor Subspace Clustering and Completion for Subway Ridership Analysis

Nurettin Dorukhan Sergin, Arizona State University, 1012 E. Marigold Lane, Tempe, AZ, 85281, United States, nsergin@asu.edu, Hao Yan, Fugee Tsung

Subway turnstiles in metropolitan areas collect vast amounts of data which can be used to address various problems. In this paper, we take the case for Hong Kong, which has a modern subway system that generates high-frequency, rider-level, large-scale turnstile data. We specifically address the problem of detecting system-level changes, which might be useful for gaining insights and proactive decision making for subway management. Our approach considers a graph-regularized joint subspace clustering and completion method to be able to group and forecast stations. The performances of these two tasks will be enhanced using some known network information using graph regularization techniques.

3 - Spatial-temporal Burst Detection in Water Distribution System via Penalized Model Decomposition

Yinwei Zhang, University of Arizona, Tucson, AZ, 85705, United States, zhangyinwei@email.arizona.edu, Jian Liu, Kevin Lansey

It is crucial to develop effective and efficient algorithms to detect bursts in water distribution systems from spatially and temporally correlated hydraulic measurements. Traditional anomaly detection methods based on basis expansion may be applicable, falling short of accurate estimations of burst magnitude and starting time. This research proposes a spatio-temporal decomposition based burst detection method, which estimates the ST profile parameters according to the expected magnitude of spars burst. The effectiveness of the proposed method is demonstrated by a simulation case study.

4 - A Spatiotemporal Prediction Approach for a Three-dimensional Thermal Field with Sparse Data

Di Wang, Peking University, Beijing, China, dwang375@wisc.edu, Kaibo Liu, Xi Zhang

An accurate prediction of thermal field distribution, that is, acquiring any location of interest in a thermal field at the present and future time, is essential to provide useful information for the surveillance, maintenance, and improvement of a thermal system. However, thermal field prediction using data acquired from sensor networks is challenging due to data sparsity and missing data problems. To address this issue, we propose a field spatiotemporal prediction approach based on transfer learning techniques by studying the dynamics of a 3D thermal field from multiple homogeneous fields. A real case study of thermal fields during grain storage is conducted to validate our proposed approach.

■ TD60

CC- Chelan 4

High Dimensional Data Analysis and its Applications in Systems Informatics and Control

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Mostafa Reisi Gahrooei, Georgia Tech, Atlanta, GA, United States

Co-Chair: Kamran Paynabar, Georgia Tech, Atlanta, GA, United States

1 - Personalized Learning System for Smart Transportation Demand Management

Jingshuo Feng, University of Washington, Seattle, WA, United States, jingsf@uw.edu, Xi Zhu, Feilong Wang, Shuai Huang, Cynthia Chen

With the rapid proliferation of smart personal technologies, Transportation demand management (TDM) at the individual level is now possible. In this presentation, we will introduce our ongoing works in developing new analytic methods that can statistically accurately to estimate individual's travel preference from their behavior data (sample size limited and fragmented), computationally efficient to implement, and easy to be integrated with dynamic incentive optimization methods to modify individuals' travel behaviors to achieve optimal solutions in both system-level and individual-level goals.

2 - Weakly Dependent Tensor Completion with Multinetwork Information Based on Metro Passenger Flow Prediction

Ziyue Li, The Hong Kong University of Science and Technology, Kowloon, Hong Kong, Nurettin Dorukhan Sergin, Hao Yan, Chen Zhang, Fugee Tsung

Tensor completion has attracted amounts of research. Most of them focus on low-rank property either by adding nuclear norm on tensor or penalty on the decomposed components. But low-rank assumption cannot always be satisfied especially when the data present complex and diverse dependencies. Spatiotemporal data is one of the good examples. By introducing the weakly dependent penalty and forming the inter-dependency network, the completion accuracy is improved remarkably. This is formulated in both CANDECOMP / PARAFAC (CP) and Tucker decomposition form. In the end, an implementation based on passenger traffic flow data in Hong Kong is conducted and proves our method's accuracy.

3 - System-level Root Cause Diagnostics in Modern Multistage Manufacturing Systems

Andi Wang, GaTech, Atlanta, GA, United States, andi.wang@gatech.edu, Jianjun Shi

Modern multistage manufacturing processes (MMPs) generate heterogeneous data from different stages. This study proposes a modeling framework to describe the relationship between inputs and the process data, by considering distinct characteristics of the process data from stages, the sparsity of the inputs' effect and the limited variation pattern of the data from each stage and proposed a solution procedure.

4 - Predictive Analytics for Complex Systems Using High-dimensional Signals

Amirreza Sahebi Fakhrabad, NC, United States, Xiaolei Fang

The high-dimensionality and nonlinearity of degradation signals have posed significant challenges to the remaining useful lifetime prediction of complex engineering systems. To address these challenges, this talk proposes a new manifold learning-based methodology, which captures the nonlinear characteristic and reduces the dimensionality of degradation signals. In addition, an incremental updating algorithm is developed to speed up the computation. Numerical studies are used to validate the effectiveness of the proposed method.

5 - Interval-based Sequential Design for the Exploration and Estimation of a Response Surface

Alessia Benevento, University of Salento, Lecce, Italy, Swati Gupta, Massimo Pacella, Kamran Paynabar

Sequential sampling methods are used to estimate functions describing models subjected to expensive simulations. These methods provide rules for the selection of new points of the domain in order to capture the largest number of information about the function. We propose a new sequential method aiming at estimating a response surface. In contrast with the existing methods, our method is very simple and extremely fast, as it does not involve the estimation of the function at each iteration. On the other hand, it shows the same performances of other methods in terms of accuracy. The performance of the proposed algorithm is evaluated through numerical simulations and then applied to a real study-case.

■ TD61

CC- Chelan 5

Joint Session QSR/HAS: Data Analytics and Machine Learning: Methodologies and Applications in Healthcare Systems

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Bing Si, State University of New York at Binghamton, Binghamton, NY, 13905, United States

1 - Active Learning with Gaussian Processes for Determining Optimal Locations to Biopsy Brain Tumor

Nathan B. Gaw, Graduate Research Associate, Arizona State University, Tempe, AZ, 85258, United States, ngaw1@asu.edu, Jing Li

Glioblastoma (GBM) brain cancer ranks among the most deadly of all human cancers. Thus, it is crucial to have tools that accurately predict tumor heterogeneity and extent of tumor invasion. Previously, machine learning has been used to combine image-localized biopsies and imaging data to make predictive maps of tumor cell density. However, there has not been consideration to select biopsies to minimize prediction map uncertainty. The current study aims to utilize active learning with Gaussian processes to determine optimal locations to biopsy with the goal of minimizing uncertainty in tumor cell density prediction maps.

2 - Kidney Viability Forecasting by General Path Model and Biopsy Location Recommendation

Qing Lan, Virginia Tech, Blacksburg, VA, United States, qing83@vt.edu, Xiaoyu Chen, John Robertson, Ran Jin

The focus of this paper is to forecast the viability of heterogeneous kidneys leading to the success of transplantation. Current machine perfusion system does not provide guideline for selecting biopsy time and location which requires repeated biopsy to evaluate the viability. We propose a multi-task general path model with Bayesian updating that forecasts the viability during the preservation process, thus can provide recommend the time and location of conducting biopsy to reduce the risk of damaging kidney. This method is validated in a case study of preserving porcine kidney. Therefore, the utilization of donor kidney can be potentially increased to benefit more end-stage patients.

3 - Markov Optimal Intervention Strategies for Breast and Ovarian Cancers

Farhad Imani, The Pennsylvania State University, Leonhard Building, State College, PA, 16802, United States, Bing Yao, Conrad S. Tucker, Hui Yang

BRCA1/2 mutation carriers have a high risk of breast and ovarian cancers. While there is no decisive method for avoiding breast and ovarian cancer, making decisions about intervention strategies (i.e., consist of the prophylactic surgeries and screening) for early signs of the disease may lead to the efficient treatment. This paper presents a novel constrained Markov decision process to effectively determine policies for sequential stochastic decision problems where multiple rewards are concurrently considered. The optimization algorithms are developed to find cost and quality-adjusted life years optimal intervention strategies for those who are tested positive for a BRCA1/2 mutation.

4 - A Behavior Study on Swing Shift Dynamic Performance Response to Emergency Department Workload Uncertainty

Jianing Man, Mayo Clinic, Rochester, MN, 55902, United States, Man.Jianing@mayo.edu, Mustafa Y. Sir, Kalyan Pasupathy, David L. Kaufman, Daniel Cabrera

In the emergency department (ED), patient care demand fluctuates every day due to variability in patient arrivals and clinical acuity. In order to manage healthcare resource utilization and mitigate burnout among providers, the Department of Emergency at Mayo Clinic Saint Marys Hospital in Rochester, MN, developed and adopted an adaptive swing overnight shift, which runs parallel to a regular overnight shift. In this study, we explore if the trends in overnight score impact the admission rate, patients' length of stay, and other performance metrics through behavioral interventions for physicians staffing the swing shift compared to the regular shift.

5 - A Novel Structural Equation Model for Screening Behaviors Prediction and Health Promotion

Bing Si, State University of New York at Binghamton, Binghamton, NY, 13905, United States, bsi@binghamton.edu

Routine screening is a cost-effective secondary prevention administrated by healthcare providers (HCPs) for healthcare promotion. A newly developed Instruments of American Association of Nurse Practitioners (IAANP) enables quantitative data to be collected. A novel structural equation model is developed for the prediction of HCP's screening behaviros from IAANP data. The findings of the research can promote routine screening in healthcare settings by optimizing the HCPs' training, education, and practice environment, eventually leading to improved quality of care and clinical outcomes.

■ TD62

CC- Tahoma 1

Data-Driven Operations Management and Policy-Making in Healthcare

Sponsored: Health Applications

Sponsored Session

Chair: Mehmet Ayvaci, The University of Texas at Dallas, Richardson, TX, United States

Co-Chair: Ozalp Ozer, The University of Texas at Dallas, Richardson, TX, 75080-3021, United States

1 - An Analytics Approach to Guiding Randomized Control Trial Design in Hypertension Management

Anthony Bonifonte, Denison University, Granville, OH, 30106, United States, bonifontea@denison.edu, Turgay Ayer, Ben A. Haaland

Antihypertensive drug treatment can control elevated blood pressure and reduce the risk of cardiovascular disease. We propose data-driven models that combine stochastic optimization and statistics to identify the optimal joint systolic and diastolic thresholds for initiating treatment. We analytically characterize the expected value of the hazard experience by patients and compute the optimal treatment initiation decisions. We conduct a simulation model to estimate the potential societal impact from implementing our treatment policy. Our findings may help guide future RCT design and suggest treatment thresholds should depend jointly on systolic and diastolic pressure.

2 - Adaptive Clinical Trial Design with Surrogates: When Should We Bother

Arielle E. Anderer, The Wharton School, Philadelphia, PA, United States, aanderer@wharton.upenn.edu, Hamsa Sridhar Bastani, John M. Silberholz

Surrogate outcomes have long been used in clinical trials when the true outcome of interest is expensive, time consuming, or otherwise difficult to measure. In this work we propose optimal adaptive clinical trial designs that integrate surrogate and true outcomes, and we analytically and empirically characterize regimes where our designs are especially beneficial.

3 - Predicting Patient-level Antibiotic Adherence

Isabelle Rao, Stanford University, Stanford, CA, United States, isarao@stanford.edu, Adir Shaham, Amir Yavneh, Dor Kahana, Itai Ashlagi, Dan Yamin, Margaret L. Brandeau

Low medication adherence is a leading problem in developed countries, causing a substantial health and economic burden. We develop machine learning algorithms that utilize demographic and electronic medical record data to predict the probability that a patient will purchase a prescribed antibiotic medication. In-depth analysis of patient-level data, leading to accurate prediction, can yield insights into individual decision making associated with prescription medications, and can help shape the next generation of personalized intervention strategies.

4 - Data-Driven Personalized Early Detection of Sepsis

Zahra Mobini, The University of Texas at Dallas, Richardson, TX, United States, zahra.mobinidehkordi@utdallas.edu, Mehmet Ayvaci, Ozalp Ozer

We develop an alerting mechanism for early detection of sepsis that accounts for both an individual patient's risk factors and the caregiver's compliance with alert-driven care processes. We formulate the problem of determining when to alert sepsis as a discrete-time, finite-horizon Markov Decision Process and structurally characterize threshold policies. We empirically validate our model using real clinical data and demonstrate how the proposed alerting mechanism can improve patient outcomes in the hospital.

■ TD63

CC- Tahoma 2

Healthcare Operations

Sponsored: Health Applications

Sponsored Session

Chair: Huiyin Ouyang, Hong Kong

Co-Chair: Serhan Ziya, University of North Carolina, Chapel Hill, NC, 27599, United States

1 - Optimizing Pediatric Vaccine Administration Policies in Developing Countries from a Societal Perspective

Gizem S. Nemutlu, Harvard Medical School and MGH, Boston, MA, United States, gnemutlu@mgh.harvard.edu, Fatih Safa Erenay, Osman Y. Ozaltin

Pediatric vaccination programs in developing countries suffer from open-vial wastage. We propose using multi-dose vaccine vials of different sizes and formulate a Markov decision process (MDP) model to minimize the societal cost of vaccine administration policies. Using data for routine pediatric vaccines, we show that the proposed policies significantly reduce the open-vial wastage. We also determine the best initial inventory level combination that improves the demand coverage up to target levels without early termination of service while incurring reasonably small or no additional cost.

2 - Integrating Mortality Prediction Algorithms with Physician Decisions to Improve End-of-Life Care

Junchao Ma, Yale SOM, New Haven, CT, 06511, United States, junchao.ma@yale.edu, Edieal J. Pinker, Donald Lee

End-of-life care for advanced cancer patients is aggressive and costly. Hospice referrals require a clinical judgment that a patient's survival time is less than six months. According to data we collected, the median length of hospice stays until death was only 17 days. Studies showed that physicians' estimates of patient survival time to be inconsistent and over-positive, leading to late referral to hospice. To address this issue, we developed a decision support tool that used a machine learning algorithm to predict short-term mortality based on EMR data feed. We will talk about our attempt to understand how our prognostic tool can augment oncologists' decision making.

3 - Robust Optimization on Healthcare Referral Networks: Engaging Providers in Developing Countries

Clara Stoesser, University of Toronto, Toronto, ON, Canada, clara.stoesser@mail.utoronto.ca, Timothy Chan, Sarang Deo, Justin J. Boutilier

Private healthcare providers (PPs) are commonly used in low- income countries but their diagnostic techniques are often inadequate, so third party agencies engage with PPs to improve their health practices. In this project, we develop a methodology to determine the set of providers that these engagement programs should interact with in order to maximize the number of patients who will be properly diagnosed given program budget constraints and uncertain referral data. We simulate potential instances of the referral network and then use a robust optimization model to determine the optimal set of PPs. Field data on improving tuberculosis diagnosis in Mumbai is applied to this framework.

4 - Allocation of Intensive Care Unit Beds with Patient Readmission

Huiyin Ouyang, Assistant Professor, The University of Hong Kong, Hong Kong, huiyin.ouyang@hku.hk, Zhankun Sun, Sukriye Nilay Argon, Serhan Ziya

This work aims to use mathematical modeling and analysis to develop insights into and policies for making priority decisions in Intensive Care Units (ICUs) with patient readmissions. We assume patients' health conditions may change over time, and patients who are early discharged from ICU due to capacity constraint might get readmitted to ICU when beds become available later. We propose a stylized mathematical model in which patients' health conditions change over time according to a Markov chain. We formulate this decision problem as a Markov decision process and provide some analysis of the structure of the optimal policy.

■ TD64

CC- Tahoma 3

Joint Session HAS/Practice Curated: Incentive and Policy Design

Sponsored: Health Applications

Sponsored Session

Chair: Tinglong Dai, Johns Hopkins University, Baltimore, MD, 21202, United States

1 - Reference Pricing for Healthcare Services

Hamed Mamani, University of Washington, Dept of Info Systems & Operations Management, Michael G. Foster School of Business, Seattle, WA, 98195-3226, United States, hmamani@uw.edu, Shima Nassiri, Elodie Adida

The traditional healthcare payment system does not incentivize hospitals to limit their prices. Reference pricing (RP) has been proposed as a way to better align incentives. Under RP, patients may be responsible for part of the cost. We propose a model to analyze RP and compare it to the traditional cost-sharing mechanisms.

2 - Vertical Integration and Quality: Evidence from the Specialists-hospital Integration

Lina Song, Harvard University, Cambridge, MA, United States, Soroush Saghafian, Mary Beth Landrum, John Hsu, Joseph P. Newhouse

Hospitals and physicians increasingly are consolidating (“vertical integration”) in the U.S. healthcare system. In theory, consolidation could achieve better clinical integration, but also increase unnecessary use or reduce quality. We empirically examine how vertical integration affects care quality through gastroenterologists’ provision of colorectal cancer screening and diagnosis. We find the evidence of a reduction in quality (i.e., increase in complications and bleeding post-colonoscopy) after physicians vertically integrate, which is mainly driven by lower use of appropriate anesthesia. Our results suggest that financial integration does not ensure quality improvement.

3 - Physician Peer Effects on Speed and Quality: Evidence from the Emergency Department

Raha Imanirad, Harvard Business School, Boston, MA, 02472, United States, rimanirad@hbs.edu, Soroush Saghafian, Stephen Traub

In this study, we estimate peer effects in the context of an Emergency Department (ED) setting by addressing the question of whether peer physicians’ characteristics including relative performance, experience, type of medical degree, and gender affect a physician’s performance. We find strong evidence that physicians affect each other’s speed and quality in opposite directions and scheduling diverse peers during the same shift could have a positive net impact on the operations of a hospital ED. We identify resource spillover as the main driver of peer effects and show that, under high ED volumes (when the shared resources are most constrained), the magnitude of the observed peer effects increases.

4 - Monitoring Policy Optimization for HIV Patients with Heterogeneous Adherence Types

Zhenhuan Zhang, PhD Candidate, University of Minnesota, Minneapolis, MN, 55414, United States, Diana Maria Negoescu

In chronic disease management, as many as 40% of patients fail to adhere to treatment recommendations. Poor adherence leads to a waste of medical resources, higher rates of treatment failure on designated therapies and worsened health outcomes. Personalized treatment plans adapted to heterogeneous patient adherence patterns might yield better health outcome. We develop a Markov decision process model to optimize the monitoring interval for HIV-infected patients on the first-line antiretroviral therapies (ART) regimen in resource-limited settings, with heterogeneous patient adherence behavior.

5 - Squeeze in: Can Last-minute Surgical Reservations Hurt Patient Outcomes?

Tinglong Dai, Johns Hopkins University, Baltimore, MD, 21202, United States, dai@jhu.edu, Soo-Hoo Lee, Philip H. Phan, Nehama Moran, Jerry Stonemetz

The newsvendor paradigm has influenced much of the empirical operations management literature on operating-room (OR) management. Our observations of actual clinical practice, however, revealed a pattern of scheduling accuracy that is opposite to what the newsvendor paradigm would predict. To account for this gap, we collected and analyzed a large dataset that captures not only ex antefactors that a surgeon is aware of when reserving an OR, but also ex postfactors that the surgeon might face on the day of the case. We show that surgeons consistently under-booked OR times when the time to surgery is short. We also establish how the squeeze-in effect drives patient outcomes.

■ TD65

CC- Tahoma 4

Empirical Research in Healthcare Operations

Sponsored: Health Applications

Sponsored Session

Chair: Ujjal Kumar Mukherjee, University of Illinois, Urbana-Champaign, Champaign, IL, 61820, United States

Co-Chair: Han Ye, U. of Illinois at Urbana-Champaign, Champaign, IL, 61820, United States

1 - Examining the Impact of Hospital Internal and External Factors on Bias in Medical Treatment

Luv Sharma, University of South Carolina, Columbia, SC, 29206, United States, luv.sharma@moore.sc.edu

This study looks at hospitals, patients, legislative, and market specific factors that can lead to biases in medical treatment as well as conditions under which these biases negatively influence clinical outcomes.

2 - The Impact of Freelancers on Cost Performance in Hospitals

Yingchao Lan, Assistant Professor, University of Nebraska-Lincoln, Lincoln, NE, 68506, United States, yingchao.lan@unl.edu, Deepa Wani, Aravind Chandrasekaran

The share of hospitals with integrated physicians has been increasing recently. The implicit assumption is that integrated physicians can bring in more patient volume, improve efficiency, enable close collaboration through established familiarity, and thus reduce cost. However, the cost implications of such a trend is not clear. We assemble a unique patient-level panel data to empirically explore to what degree freelancers (physicians) explain the cost performance of hospitals? Further, if the relationship is moderated by physician-level (tenure) and hospital level (accountable care organization participation) characteristic.

3 - The Impacts of Patients’ Sentiment Trajectory Features on Their Willingness to Share in Online Support Groups

Yu Wei Lin, University of Illinois, Champaign, IL, United States, Mehmet Eren Ahsen, Michael J. Shaw, Sridhar Seshadri

Online support groups are valuable resources for patients by providing them emotional support from other patients with similar experiences. Little research has systematically examined how patients’ sentiment trajectory features affect patients’ engagement behaviors in OSGs. We study the impact of patients’ sentiment trajectory features in online social networks on their willingness to share. Our analysis suggests that patients’ sentiment positivity, stability, and dispersion positively affect patients’ willingness to share. Moreover, we found that patients’ sentiment trajectory features can be influenced by (1) their online interactions and (2) their offline life events.

4 - Towards Mitigation of Healthcare Outcome Disparity in Chronic Diabetes Care

Han Ye, U. of Illinois at Urbana-Champaign, Champaign, IL, 61820, United States, hanye@illinois.edu, Ujjal Mukherjee, Dilip Chhajed

In this paper we investigate moderating effect of spatial, infrastructural, and operational accesses that healthcare delivery organizations can use to mitigate some of the socioeconomic sources of disparity in diabetes care.

■ TD66

CC- Tahoma 5

Joint Session QSR/DM: Statistical Data Mining Approaches for Diverse Manufacturing Processes

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Youngseon Jeong, Chonnam National University, Korea, Republic of

Co-Chair: Sangahn Kim, Siena College, Loudonville, NY, 12211, United States

1 - A New Cluster Validity Index in Feature Space

Youngseon Jeong, PhD, Chonnam National University

Please check the mobile app for this abstract.

2 - Monitoring and Control of High-dimensional Data via Sparse Group Lasso

Sangahn Kim, Siena College, Loudonville, NY, 12211, United States, skim@siena.edu, Myong Kee Jeong, Elsayed A. Elsayed, Mehmet Turkoz

In high-dimensional processes, a large number of process parameters or quality characteristics are found to be featured through their dependencies and relevance. The features that have similar characteristics or behaviors in the process operation can be categorized into multiple groups. This research proposes a new method to monitor the high-dimensional process when the grouped structure in the behavior of the process is observed.

3 - Residual-based Surface Segmentation for Monitoring Three-dimensional Surface Topography

Jaeseung Baek, Rutgers University, Piscataway, NJ, United States, Myong Kee Jeong, Elsayed A. Elsayed

Monitoring the three-dimensional (3D) surface topographic variations is important and challenging for quality engineers. This paper investigates a new approach for detecting topographic variations in 3D surfaces. We develop a residual-based separation deviation (RBSD) model to segment the surface and identify the topographic variations in the surface, and introduce a spatial randomness-based monitoring statistic to detect anomalies in the surface topography. Numerical simulation and case study of paper surface monitoring demonstrate the effectiveness of our approach.

■ TD67

S- Virginia

Statistical Learning and Decision-Making

Sponsored: Simulation

Sponsored Session

Chair: Ilya O. Ryzhov, University of Maryland, College Park, MD, 20742, United States

1 - Adaptive Personalized Dose Finding Clinical Trials

Saeid Delshad, Clemson University, Clemson, SC, United States, sdelsha@g.clemson.edu, Amin Khademi

This work studies optimal sequential allocation of heterogeneous patients to treatment doses in a dose-finding clinical trial, where the decision maker seeks to find the best dose for each patient group. We follow a Bayesian set up for this problem and show several statistical properties of two heuristics. We show the results based on real data.

2 - Learning for Adaptive Elimination in Parallel Ranking and Selection

Linda Pei, Northwestern University, Evanston, IL, 60202, United States, Barry L. Nelson, Susan R. Hunter

Simulation ranking and selection methods, in which all feasible solutions are simulated, have traditionally exploited pairwise comparisons which are a computational bottleneck in large-scale problems. We propose a method for use within a parallel master-worker framework in which the master adaptively learns a standard that it communicates to workers who sequentially simulate solutions and eliminates solutions deemed inferior to the standard. We show that this method guarantees a desired expected false elimination rate, and we investigate computational advantages and asymptotic behavior.

3 - Inference on Average Treatment Effects in Aggregate Panel Data Settings

Yinchu Zhu, University of Oregon, Eugene, OR, 97401, United States, yzhu6@uoregon.edu, Victor Chernozhukov, Kaspar Wuthrich

This paper studies inference on treatment effects in aggregate panel data settings with a single treated unit and many control units. We propose new methods for making inference on average treatment effects in settings where both the number of pre-treatment and the number of post-treatment periods are large. The counterfactuals are estimated using constrained Lasso, an essentially tuning free regression approach that nests difference-in-differences and synthetic control as special cases. The test is very easy to implement and demonstrates an excellent performance in simulation experiments, and is taken to a data application, where we re-evaluate the economic consequences of terrorism.

4 - Data-Driven Robust Resource Allocation with Isotonic Cost Functions

Ilya O. Ryzhov, Associate Professor, University of Maryland, Robert H. Smith School of Business, College Park, MD, 20742, United States, iryzhov@rhsmith.umd.edu, Ye Chen, Nikola Markovic, Paul Schonfeld

We consider two-stage planning problems in which a resource is first divided among a set of independent regions, and then costs are incurred based on the allocation to each region. Costs are assumed to be decreasing in the quantity of the resource, but their precise values are unknown, for example if they represent difficult expected values. We develop a new data-driven uncertainty model for isotonic cost functions, which can be used in conjunction with robust optimization to obtain tractable allocation decisions that significantly improve worst-case performance outcomes.

■ TD68

S- University

Joint Session Sharing Econ & Crowdsourcing/Practice Curated: Shared Mobility Systems

Emerging Topic: Sharing Economy & Crowdsourcing

Emerging Topic Session

Chair: Samitha Samaranayake, Cornell University, Ithaca, NY, 14853, United States

1 - Where Do We Go from Here: Rebalancing an Autonomous Rideshare Fleet

Chinmoy Dutta, Lyft, San Francisco, CA, 94040, United States, cdutta@lyft.com, Garrett van Ryzin

A mobility-on-demand (MoD) system must cope with the time-varying asymmetry in demand flows leading to spatial imbalance of originating ride demand and available vehicles to service them. With ability to directly control the vehicles, an autonomous MoD (AMoD) system can tackle this challenge directly and effectively by rebalancing vehicles. We propose a novel approach to rebalancing by formulating the problem as a two-stage stochastic integer program with recourse. Our approach can cope with future uncertainty by making decisions hedging against possible future scenarios, while appropriately modeling the intricate interplay between dispatching and rebalancing.

2 - Algorithmic Challenges in Enabling High-capacity Ride Pooling Services

Juan Carlos M. Mori, Cornell University, Ithaca, NY, United States, Samitha Samaranayake

The rapid expansion of on-demand ride-hailing services has changed the transportation eco-system worldwide. While these services are a valuable alternative travel mode, as evident by their popularity, there are many questions regarding their scalability, efficiency, equity and negative externalities (e.g. congestion, pollution etc.). One way to mitigate some of these concerns is to consider high-capacity ride-pooling services that operate like an on-demand transit service. This talk will discuss the algorithmic challenges in operating such a system at-scale and present techniques for overcoming some of these challenges.

3 - Contracting for on Demand Public Transit

Sherwin Doroudi, University of Minnesota, MN, Minneapolis, MN, 55455, United States, sdoroudi@umn.edu, Philipp Afeche, Varun Gupta, Ankur Mani, Daniel F. Silva, Alexander Vinel

We present preliminary work addressing several questions on the design of an on demand public transit system contract between a transportation provider and a city. Specifically, we seek to investigate (i) the operator's optimal decisions given a contract and city structure (including demand patterns), (ii) the resulting quality of service in each region under said decisions, and (iii) the costs incurred by the city under said decisions. Together, addressing these questions should allow us to determine what types of contracts are most beneficial (or even feasible) for a city, given a set of (potentially region- and demographic-dependent) quality of service and equity constraints.

4 - Robust Trip Sharing for Urban Commuting

Pascal Van Hentenryck, Georgia Institute of Technology, Atlanta, GA, 30332, United States, Mohd Hafiz Hasan

This presentation considers the problem of minimizing the number of cars on the road for urban commuting, reducing parking pressure and congestion. It presents the robust trip sharing problem that combines stochastic optimization, branch and price, and real-time optimization in order to achieve this objective. Experimental results on a real case study demonstrate the potential benefits of the approach.

■ TD69

S- Seneca

Resource Management in Network-based ICT Systems

Sponsored: Telecommunications and Network Analytics

Sponsored Session

Chair: Young Myoung Ko, Pohang University of Science and Technology, Pohang, 790-784, Korea, Republic of

1 - Optimizing Slicing Parameters on a 5g Transport Network

Neil Diaz, Texas A&M University, Dept of Industrial and Systems Engineering, College Station, TX, 77843-3131, United States, nodiaz@tamu.edu, Natarajan Gautam

Latency estimation on a 5G network slice is crucial to allow Infrastructure Providers to provision resources to satisfy customer's expected quality of service while securing isolation for their traffic. However, latency estimation is challenging since Time-Sensitive Networking uses a combination of statistical and time-division multiplexing to create these slices in the Transport Network. We adapt the fixed-cycle traffic-light queue in urban traffic literature to obtain quality-of-service metrics and optimize network-slicing parameters. We discuss the techniques' strengths and weaknesses after performing various numerical experiments.

2 - On the Possibility and Economic Impacts of Spectrum Sharing: A South Korean Case

Jeonghoon Mo, Yonsei University, Seoul, 03722, Korea, Republic of, j.mo@yonsei.ac.kr, Tae Yoel Kim

Due to reduced wireless network cycles, the higher infrastructure cost become a big burden for wireless operators. The spectrum sharing between providers can be a possible solution to save infrastructure cost for operators even though it has not been realized. In this study, we consider a few possible spectrum sharing scenarios between operators and evaluate possibility of the spectrum sharing and its economic impacts using the South Korean case. The study suggests that the direct spectrum sharing methods between mobile network operators are more effective than sharing the public frequency like LSA and CBRS. The economic impacts due to spectrum sharing for 5G service could be as large as $1.3~4.6B.

3 - Impact of Quality of Service Guarantee on Energy Efficiency in Data Centers

Soongeol Kwon, Binghamton University, SUNY, 4400 Vestal Pkwy E, Systems Science and Industrial Engineering, Binghamton, NY, 13902, United States, skwon@binghamton.edu

For the efforts to achieve energy-efficient and sustainable data center operations, quality of service (QoS) should be guaranteed at the desired level to respond to users' requests with their satisfaction. Given this context, this study intends to develop a two-stage stochastic programming that is designed to investigate optimal data center operations based on demand response to reduce energy cost while ensuring the desired QoS level against the stochastic workloads. Then, additional chance constraint and risk constraint are introduced as means of managing the level of QoS guarantee to evaluates the impact of QoS guarantee with different levels on energy efficiency.

4 - A Robust Optimization Approach for Server Speed Scaling and Load Balancing in Data Centers with Service-level Agreements

Seung Min Baik, Pohang University of Science and Technology, Korea, Republic of, seungmin.baik@lstlab.org, Minseok Kim, Young Myoung Ko, Soondo Hong

Data Centers are processing various ICT service requests for their customers, and service-level agreements (SLAs) with customers work as hard constraints that data centers should satisfy. Data centers tend to run servers faster than required to comply with the SLA under uncertainty, which may cause energy inefficiency in operations of data centers. In this talk, we model servers in data centers using G/G/1/PS queues and minimize energy consumption while maintaining the SLA - the probability of waiting time exceeding a threshold. We derive static server speeds and workload routing probabilities through a robust optimization model by expressing the random variables' domain as uncertainty sets.

■ TD70

S- Jefferson A

Economics of Digital Platforms

Sponsored: EBusiness

Sponsored Session

Chair: Tingting Nian, University of California, New York, NY, 10012, United States

1 - How Does Algorithmic Trading Influence Investor Participation in Peer-to-Peer Online Lending Markets?

Hongchang Wang, Georgia Institute of Technology, Atlanta, GA, 30126, United States, hongchang.wang@scheller.gatech.edu, Eric Overby

Algorithmic trading has reshaped equity markets and had significant effects on market performance. In this paper, we examine the effect of algorithmic trading in online peer-to-peer lending markets. To study this, we examine the effect of an API upgrade on Prosper.com that facilitated algorithmic trading. Using a difference-in-differences strategy, we find that individual "manual" investors were crowded out of the most quickly-funded and typically best-performing loans after the API upgrade. However, the API upgrade may have increased the size of the market, thereby allowing individual investors to continue investing in the market, albeit for somewhat lower quality loans.

2 - Home Bias in Online Employment: Evidence from an Online Labor Market

Chen Liang, University of Connecticut, Storrs, CT, 85282, United States, Yili Hong, Bin Gu

We study the nature of home bias in online employment—an employer preference for workers from his or her home country. Using a unique large-scale data set from a major online labor market containing employers' consideration sets and ultimate choices, we estimate employers' home bias. Further, we disentangle two types of home bias—statistical and taste-based home bias—using a quasi-natural experiment based on the introduction of a monitoring system, which enables employers to easily observe workers' effort on time-based projects. Finally, we study heterogeneity in home bias across employers from different countries with a post-treatment sample with minimal statistical discrimination.

3 - Preference, Profitability, and Ranking in Mobile App Monetization

Shengjun Mao, University of California Irvine, Irvine, CA, United States, shengjum@uci.edu, Sanjeev Dewan, Yi-Jen (Ian) Ho

We develop a structural empirical framework for estimating consumer click and conversion utility based on mobile clickstream data, readily available from server logs. We have access to unique data on app distribution, including individual CPA margins, from a large mobile services operator. Consumer click and conversion utilities are jointly estimated as a function of screen rank along with a variety of quantitative and qualitative factors. We conduct policy experiments to examine the effectiveness of alternative screen ranking strategies, finding that a personalized ranking scheme that accounts for both utility and margins outperforms methods based on margins alone or utility alone.

■ TD71

S- Jefferson B

Behavioral Operations Topics

Sponsored: Behavioral Operations Management

Sponsored Session

Chair: Brent Moritz, Penn State University, University Park, PA, 16802, United States

1 - Construal Level and Inventory Decisions

Brent Moritz, Penn State University, Smeal College of Business, University Park, PA, 16802, United States, bmoritz@psu.edu, Sam Kirshner

We investigate whether construal levels impact inventory management in a newsvendor task. In two experiments, we find that individuals primed with a high construal level (abstract focus) are more pulled-to-center and have lower expected profits than the participants primed with a low construal level (concrete focus).

2 - Wholesale Price Contracts Versus Capacity Reservation Contracts under Information Sharing: A Behavioral Investigation

Sebastian Schiffels, Technical University Munich, Munich, 80333, Germany, Guido Voigt

We address the question whether non-linear contracts outperform wholesale price contracts in a setup where a manufacturer has private information on end-customer demand that is of relevance for the supplier's capacity decision. Our experimental study with 234 subjects provides an internally valid comparison of both contract types when information sharing is possible. The comparison reveals that non-linear contracts may outperform wholesale-price contracts even though we observe that wholesale price contracts perform better than theoretically predicted while non-linear contracts perform worse than theoretically predicted which is in line with previous studies.

3 - Delegation Between Humans and AI: An Experimental Investigation of the Future of Work

Andreas Fuegener, University of Cologne, Albertus-Magnus-Platz, Cologne, 50923, Germany, andreas.fuegener@gmail.com

A defining question of our age is how AI will influence the workplace of the future and, thereby, the human condition. The dominant perspective is that the competition between AI and humans will be won by either humans or machines. We argue that the future workplace may not belong exclusively to humans or machines. Instead, it is better to use AI together with humans by combining their unique characteristics and abilities. In three experimental studies, we let humans and a state of the art AI classify images alone and together. We present novel insights with impact on human-AI collaboration at the workplace.

4 - An Experimental Study of Strategic Inventories in Dual Channel

Yan Lang, University of Texas at Arlington, Arlington, TX, United States, yan.lang@mavs.uta.edu, Kay-Yut Chen

In this paper, we use game theory analysis to determine how the retailer can gain a strategic advantage by holding inventories, in order to effectively gain market share while competing by selling quantities with the supplier who has her own direct selling channel. We also conduct a series of controlled laboratory experiments on MTurk to examine whether our research hypotheses align with human decision makers in terms of behavior changes when facing different market power and cost issues. We finally build behavior models to explain the laboratory results with bounded rationality, fairness, and strategic inventory bias.

5 - Beauty is in the Eye of the Route Planner

Yingjie Fan, Erasmus University, Rotterdam, Netherlands, fan@rsm.nl, Niels Agatz, Daan Stam

Logistics service providers often have human planners interact with automated planning systems to plan their delivery routes. Anecdotal evidence suggests that planners may not use system-generated plans that `don't look nice'. However, as far as we know, the perceived quality and visual attractiveness of vehicle routes has not yet been empirically studied. We believe that such an empirical input is required to better understand why and when human planners are more likely or less likely to accept computer generated route plans.

■ TD72

S- Columbia

Joint Session ISS/Practice Curated: Decision Making Through Optimization

Sponsored: Information Systems

Sponsored Session

Chair: Rakesh Mallipeddi

1 - A Framework for Analyzing Influencer Marketing in Social Networks: Selection and Scheduling of Influencers

Rakesh Reddy Mallipeddi, Tulane University, Mays Business School, Dept of Info & Operations, New Orleans, LA, 77843-4217, United States, Subodha Kumar, Chelliah Sriskandarajah, Yunxia Zhu

Influencer marketing, which involves employing influential users of social media, is being increasingly employed by organizations to market or advertise their products. In this talk, we present a data-driven analytical framework to answer the following questions from the marketer's perspective: • How many influencers to hire and whom to hire? • How to schedule and sequence marketer's content being promoted by multiple influencers? • What is the marginal benefit of hiring an influencer? • What are the strategies to augment the benefits of influencer marketing?

2 - How to Sell a Dataset? Pricing Policies for Data Monetization

Sameer Mehta, The University of Texas at Dallas, Richardson, TX, 75080, United States

The wide variety of pricing policies used in practice by data-sellers suggests that there are significant challenges in pricing datasets. We formulate a tractable model of a data-seller's problem of optimally pricing a dataset, and exploit its special structure to obtain near-optimal pricing policies.

3 - Rise and Fall of E-books: A Curious Case of Agency Pricing Model

Sailendra Prasanna Mishra, University of Texas at Dallas, Richardson, TX, 76201, United States, spm160530@utdallas.edu, Subodha Kumar, Liangfei Qiu

Agency pricing model allows publishers to take control over e-books and reduces the bargaining power of online retailers in setting retail prices. We study how the agency contract changes the pricing strategies for the publishers and the retailer with high cross-channel capability. The publishers with agency contract follow different pricing strategies for their books compared to strategies adopted by the retailer. Overall, our results show that the agency pricing model reduces the attractiveness of e-books from these publishers and makes their consumers worse off.

■ TD73

S- Boren

A Day in the Life

Emerging Topic: INFORMS Section on Practice

Emerging Topic Session

Chair: Rajeev Namboothiri, GE Global Research, Bangalore, 560066, India

Moderators

Rajeev Namboothiri, GE Global Research, John F. Welch Technology Centre, Bangalore, 560066, India, rajeev.namboothiri@ge.com

Hear from industry veterans about a typical day at work for an OR professional.

Panelists

- Rajeev Namboothiri, GE Global Research, John F. Welch Technology Centre, Bangalore, 560066, India, rajeev.namboothiri@ge.com
- Daniel Chen, Amazon.com, Seattle, WA, United States, chonglic@amazon.com
- William Christian, Severn, MD, 21144, United States
- Sharon Arroyo, The Boeing Company, Seattle, WA, 98124-2207, United States, sharon.f.arroyo@boeing.com

■ TD74

S- Capitol Hill

Health Care, Modeling and Optimization VI

Contributed Session

Chair: Erkin Otles, University of Michigan, Verona, WI, 53593, United States

1 - Managing Blood Inventory with Random Transfers

Srinivasa Kartikeya Puranam, Rutgers University, Camden, NJ, United States, David C. Novak, Marilyn T. Lucas

The primary objective of this research is to develop a practitioner-focused, easy-to-implement ordering heuristic to address the random transfer of blood via redistribution. Here, we present results of detailed sensitivity analyses which should provide practitioners with ordering guidance given the potentially high degree of uncertainty in some cost parameters.

2 - Supervised and Unsupervised Learning of Heart Disease Patients: A Case Study of Iranian Patients

Samaneh Davarzani, Mississippi State University, Starkville, MS, United States, Ruholla Jafari-Marandi, Brian K. Smith

In this work, we improve the prediction accuracy of supervised learning by identifying patterns in the dataset using unsupervised algorithms. This is accomplished by implementing self-organizing map and K-means to identify subgroups of patients in a dataset of heart disease patients from the Iranian population. Accuracy of three prediction models including, unsupervised learning model, supervised learning model, and the presented methodology is evaluated. We find employing unsupervised learning enhances performance of supervised learning and generates more plausible prediction models for practitioners due to procedure logic, which is based on inherent characteristics of the dataset.

3 - Comparing the Prediction of Length of Stay in Hospitals Between SMOTE and W-SIMO

Surya Ayyalasomayajula, Oklahoma State University, Stillwater, OK, United States, suryaba@okstate.edu, Ankita Srivastava, Dursun Delen

Length of Stay (LOS) prediction based on the information available at the time of admission to the hospital is very important for operational planning. The proportion of patients staying in a hospital for short, medium and long duration is imbalanced. Over-sampling the minority class or using SMOTE is one of the most promising remedies for imbalanced data learning. We test the performance of oversampling, SMOTE and the new weighted synthetic informative minority oversampling (WSIMO) algorithm proposed and tested on publicly available datasets by Piri & Delen (2017). The resultant balanced dataset will be used for prediction by single and ensemble machine learning algorithms.

4 - A Rare Event Classification Model Applied to Breast Cancer Diagnosis

Halenur Sahin, Middle East Technical University, Ankara, Turkey, halenur.sahin@metu.edu.tr, Serhan Duran, Ertan Yakici

We present a rare event classification model for the problems with class imbalance. For such problems, achieving high sensitivity and specificity simultaneously is important since it is possible to have high overall prediction rates just by assigning all the observations to the class that constitutes majority.

We utilize a MILP model with a genetic algorithm (PCM+RECGA). This model is tested with a breast cancer dataset and its performance is compared with some well-known machine learning methods. PCM+RECGA preserves its capability of detecting positive observations without sacrificing from its high detection ability of negatives in case of sparsity of positive observations.

■ TD75

S- Metropolitan Ballroom A

Flash Session IV

Flash Session

Chair: Amitava Mitra, Auburn University, Auburn, AL

1 - Evolutionary Game Analysis of Employee-organization Relationship in Sharing Economy – Based on Platform Users Supervision

Miaomiao Wang, Nanjing University of Aeronautics and Astronautics, Nanjing, China, wangmiaom_nuaa@163.com, Jie Zhang, Lu Zhang, Yan Zhao Bi

In order to study the evolutionary mechanism of employee-organization relationship under the sharing economy context,this paper introduces the perspective of supervision of platform users,establishes an evolutionary game model.It shows that the choice of employee compliance behavior and platform enterprise control strategy depend on extent of the users' supervisory,and reinforcing the users supervision can make platform enterprise strengthen supervision and improve employees behaviors.Thus platform enterprise should taking full advantage of the supervisory effect of platform users to achieve mutual trust and harmonious employee-organization relationship.

2 - Explaining and Validating Second Prices for Combinatorial Auctions

William K. Schwartz, Co-founder, Ingraham and Schwartz Auction Advisers, LLC, Arlington, VA, United States, wkschwartz@gmail.com, Allan T. Ingraham, Shreyas Ravi, Christopher T. Sojourner

National auctions of radio spectrum—complicated by scores of products, each with multiple units, yielding astronomical numbers of combinatorial winning outcomes—often stipulate pricing rules based on opportunity costs. These prices are NP-hard to compute and NP-harder to explain to bidders and thus give participants confidence payments are correct. In theory, a full proof of prices requires seeing a number of counterfactual auction results exponential in the number of bidders. In practice, a very small number of counterfactuals determine prices. We present them in a novel interface that drastically simplifies both pedagogy and auditing.

3 - Fast and Exact Simulation of Spatially Cross-correlated Images Using Circulant Embedding Method

Shengfeng Chen, Western Michigan University, Kalamazoo, MI, United States

This paper presents a generic methodology for generating multivariate cross-correlated images with Gaussian random process. The proposed approach can fast simulate a pair of full-size images with exact auto- and cross-correlation structures extracted from original images through circulant embedding method. In there, a Toeplitz correlation matrix R is embedded into a positive definite circulant matrix S. The formulated circulant matrix reduce computational load and achieve extraordinary computational complexity of order O(nlogn) . Due to the low demand in computer memories, a full-size image with millions of pixels can be realized with exact spatial auto- and cross-correlations.

4 - Optimal Policy Parameters for Two-dimensional Warranties with Options To Extend

Amitava Mitra, Professor, Auburn University, Auburn, AL, United States, mitraam@auburn.edu

Certain products, such as automobiles, have warranty policies that incorporate two dimensions, namely time since purchase of the product and usage based on mileage accumulated. If both of these parameters are less than the stipulated values in the warranty policy, in case of product failure, the manufacturer replaces or repairs the product free of charge. In many consumer durable goods, an initial warranty is offered during purchase of the product. In the event of no failure during the initial warranty, the consumer is offered the option to extend the warranty. Here, we assume that the propensity to extend warranty is influenced by the unit product price and the consumer's threshold price level.

5 - Forecasting the Demand of Mobile Clinic Services Using Heterogeneous Data

Bilal Majeed, PhD. Candidate, University of Houston, Houston, TX, United States, bmajeed2@uh.edu, Jiming Peng, Ying Lin

Demand forecasting plays an important role in the deployment of mobile clinic services as it can help a mobile clinic to maximize its coverage under limited resource. In this paper, we present a new forecasting model to predict the vaccination delinquency in census tracts based on the vaccination data in schools and demographic data from school and census tracts. For this, we first develop an association between the delinquency data in census tracts and school zones. Then we use this association and the similarity structure of the census tracts to forecast the vaccination delinquency in the census tracts. A case study in Harris County is reported to demonstrate the efficacy of the new model and technique.

6 - Finding the Best Strategy to Allocate Medical Resources to the Affected Sites

Nazanin Naderi, Youngstown State University, Youngstown, OH, United States, nnaderi@ysu.edu

In this paper, we study the problem of allocating emergency units to affected sites and casualty groups in the initial hours after sudden-onset disasters to maximize the number of survivors. Survival rate of extricated casualtiesis high in the first hours following disasters, but the number of emergency (rescue and medical) units available to service casualties is often inadequate. Optimal allocation of units to the affected sites and casualty groups is necessary to maximize the number of survivors. In this paper, we determined the best strategy to allocate rescue and medical units to affected sites.

■ TD76

S- Metropolitan Ballroom B

Operations Management/Marketing Interface I

Contributed Session

Chair: Mingjun Li, USTC, Hefei, Anhui, 230000, China

1 - Simultaneous vs. Sequential Bundling Strategies in a Distribution Channel

Chia-Wei Kuo, National Taiwan University, Taipei, Taiwan, cwkuo@ntu.edu.tw, Qianbo Yin, Kwei-Long Huang, Sean Zhou

Product bundling is a commonly used marketing tool. Our paper aims to provide explanations from the perspective of channel structure for a retailer selling a base and an add-on product/service. We consider a model in which a retailer sells base and add-on products supplied by two manufacturers. There are four channel configurations which firms are integrated or not. We find that the retail price of the sequential bundle could be lower when firms are integrated. In contrast, the sequential bundle price is lower than the simultaneous bundle when the retailer integrated with any other firm. When firms are independent, the consumers cannot enjoy the discount from sequential bundling price is lower.

2 - Channel Design and OEM Growth in a Multi-market Setup

Chia-Wei Kuo, National Taiwan University, Taipei City, Taiwan, cwkuo@ntu.edu.tw, Hsiao-Hui Lee, Ting-Kai Chang

We study how to design an OEM's direct selling channel in a multi-market setup so to sustain the OEM's business growth. In this paper, we consider an OEM producing for a brand buyer that operates in two markets: the domestic market and the international market. The OEM offer the brand a discount in exchange for using the excess capacity to produce products under the OEM's own brand and then sells these products through its selling channel. We find that the OEM direct selling channel can be a win-win-win strategy for the brand, the OEM, and consumers. Such insights are generally robust, even when we consider a cost for the OEM's selling channel, such that the OEM avoids selling the same product at too low a price.

3 - Showrooming and Webrooming: How Information Provision and Price Matching Help Retailers

Yuyun Zhong, Drexel University, Philadelphia, PA, United States, yz569@drexel.edu, Wenjing Shen, Oben Ceryan

Consumers strategically choose a product information gathering channel and product purchasing channel. Showrooming and webrooming exist when the two channels deviate. We endogenize consumers' choices of information gathering and purchasing, and examine how the online retailer provides information effectively when competing with a brick-and-mortar retailer. In addition, we study how price matching affects the two retailers.

4 - Product Bundling in Distribution Channels under Fairness Concerns

Xiang Ji, University of Science and Technology of China, Hefei, China, signji@mail.ustc.edu.cn, Yuwei Hu

We study firms' optimal decisions on product bundling in a bilateral monopoly distribution channel. We show how manufacturer-driven bundling and retailer-driven bundling are respectively influenced by the joint effect of channel decentralization and fairness concerns.

5 - Inducing Supply Chain Transparency Through Supplier Encroachment

Xu Guan, Huazhong University of Science and Technology, Wuhan, China, guanxu@hust.edu.cn, lei xiao, Baoshan Liu

This paper investigates the supplier's voluntary disclosure strategy when he can encroach on the retailer's operations by selling directly to final consumers. The establishment of direct channel expands the market potential, induces the supplier to adopt disclosure strategy more frequently, and finally leads to a higher level of information transparency in the supply chain. Since more quality information is revealed in the presence of dual-channel, the retailer is able to derive a higher ex-ante payoff from supplier encroachment while the supplier may become worse off under such a circumstance.

6 - The Strategic Role of Warm-Glow Effect in Product Bundling

Mingjun Li, University of Science and Technology of China, Hefei, Anhui, China, mjlee@mail.ustc.edu.cn, Jie Wu, Xiang Ji

Non-economic factors should be paid attention to when making business decisions. Here, we mainly focus on the social attributes of crowdfunding. We study a manufacturer's decisions on product bundling and receive an interesting finding that the manufacturer will also choose a bundle strategy when the cost is high enough.

■ TD77

S- Fremont

Scheduling IV

Contributed Session

Chair: Xiaojuan Jiang, POSTECH, Pohang, 37673, Korea, Republic of

1 - Incorporating Consecutive Working Time Restrictions into Parallel Machine Scheduling

Kan Fang, Tianjin University, Tianjin, China, kfang@tju.edu.cn, Shijin Wang

We consider an unrelated parallel machine scheduling problem with restrictions on employees' working time and break time, and the objective is to minimize the weighted sum of the makespan, the machine depreciation costs and the labor costs. To solve this problem, we developed a combinatorial Benders' decomposition based algorithm, our extensive experimental results demonstrate the efficiency of our proposed solution approaches on solving this problem.

2 - A Stochastic Optimization Approach for Scheduling Flow Shops with On-site Renewable Generation

Shasha Wang, Clemson University, Central, SC, United States, shashaw@g.clemson.edu, Harsha Gangammanavar, Scott J. Mason

On-site renewable energy represents an attractive option for manufacturing plants to save energy costs when faced with variable electricity prices. We present a multi-objective, stochastic optimization framework for scheduling flow shops with on-site renewable energy generation to minimize both the total weighted completion time of jobs and energy costs. An epsilon-constraint algorithm integrated with a stochastic decomposition approach is proposed to analyze the problem. The results from our computational experiments demonstrate the effectiveness of our proposed methodology for minimizing the two objectives of interest.

3 - A Parallel Randomized Approximation Algorithm for the Non-preemptive Single Machine Scheduling Problem

Hossein Badri, Wayne State University, Detroit, MI, United States, hossein.badri@wayne.edu, Tayebeh Bahreini, Daniel Grosu

In this paper, we design a parallel randomized approximation algorithm for the non-preemptive single machine scheduling problem with release dates and delivery times, where the objective is to minimize the completion time of all jobs (i.e., makespan). To evaluate the performance of the proposed algorithm, we perform a comprehensive experimental analysis on several instances of the problem. The results indicate that the proposed parallel algorithm can efficiently solve large instances achieving significant speedup on parallel systems with multiple cores.

4 - Approximation Algorithms for Bi-criteria Scheduling Problems

Xiaojuan Jiang, POSTECH, Pohang, Korea, Republic of, xjjiang@postech.ac.kr, Kangbok Lee

The bi-criteria scheduling problems that minimize the two most popular scheduling objectives, namely the makespan and the total completion time, are considered. Since the ideal schedules, which simultaneously minimize both objectives, are usually unachievable, it makes sense to consider a balanced schedule with reasonable approximate objective values. Thus, several (1, 2)-approximation algorithms are developed with their worst-case performance analyses on several machine settings, where 1 and 2 are the approximation ratio for both criteria, respectively. Also, the lower bound curves or Pareto curves are explored.

5 - An Efficient MIP Model for Lot-sizing and Scheduling Problems with Tardiness, and Sequence-dependent and Overlapping Setups

Ching-Lun Lin, National Chiao Tung University, Hsinchu, Taiwan, asd102600@gmail.com, Sheng-I Chen, Jo-Ying Chang

This study focuses on minimizing weighted tardiness for orders due on different periods. The problem formulated as a MIP model is established on the multi-period with sequence-dependent, carryover, and overlapping setups. An alternative formulation of sub-tour eliminations is proposed by taking advantage of setup time properties for specific problem instances. We compare the performances between the alternative formulation and the valid inequality based on the dependent set concept. The result shows that the proposed method is capable to obtain a quality solution for large problem instances.

■ TD78

S- Greenwood

Data Envelopment Analysis II

Contributed Session

Chair: Yeming Gong, EM Lyon Business School, Ecully, 69134, France

1 - Two-stage Efficiency Measurement of Non-homogenous DMUs Using the DEA Methods: An Application to Major Banks in the Digital Age

Ting Cao, Phd Candidate, York University, Toronto, ON, Canada, tingc0109@gmail.com, Murat Kristal, Wade D. Cook

The impact of digitalization on banks' performance is an emerging topic. We propose a two-stage DEA approach to measure non-homogenous DMUs' efficiencies and explore the efficiencies determinants. Partial inputs to outputs impact are considered based on the nature of DMUs' internal structures. An illustrative application to major banks in North America is included.

2 - Workload Quantification and Distribution in Socio-technical Infrastructure Management Systems

Taylan Topcu, Virginia Tech, Falls Church, VA, United States, Ning-Yuan Liu, Konstantinos P. Triantis, Bart Roets

Infrastructures are complex socio-technical systems (STSs) that rely on the collaboration between human Controllers and autonomous systems (AS) for their safety-critical control activities. While modern STSs increasingly rely on automation, uncontrollable dynamic characteristics of the infrastructure render the use of automation sub-optimal and require manual control in certain instances. We use microeconomic production theory to investigate operational data from Belgian Railways and quantify the workload distribution between humans and AS. We then use machine-learning techniques to study which uncontrollable network characteristics influence the workload distribution.

3 - The Effects of Renewable Energy Sources on the Macroeconomic Efficiency of the High- and Low-income Economies

Umit Saglam, East Tennessee State University, Johnson City, TN, United States, saglam@etsu.edu

In this study, a two-stage Data Enveloped Analysis (DEA) is developed to quantitatively evaluate the impact of renewables on macroeconomic efficiencies of the high - and low-income economies by using pre-determined inputs (labor, capital stock, and renewable energy consumption) and outputs (real GDP and carbon dioxide emission) variables. The sensitivity analysis is conducted to test the robustness of the DEA models. Tobit regression models are conducted by using the DEA results for the second stage analysis to investigate the effects of renewable energy consumptions. We hope that the results of this study shed some light on this relationship for both energy practitioners and policymakers.

4 - A Dynamic Data Envelopment Analysis on IT and Performance

Yeming Gong, Em Lyon Business School, Ecully, France, gong@em-lyon.com, Jiawen Liu, Joe Zhu, Ryad Titah

Based on data envelopment analysis (DEA), this paper first examines the linkages between IT factors, intermediate performance metrics and ultimately business outcomes empirically in an IT productivity research and advances a new conceptual perspective to investigate the IT productivity paradox. We propose a theoretical framework based on dynamic network DEA models, considering multiple periods, multiple inputs and outputs, to study and understand the IT productivity paradox.

■ TD79

S- Issaquah A

Energy I

Contributed Session

Chair: Emre Celebi, Kadir Has University, Industrial Engineering Department, Kadir Has Caddesi, Istanbul, 34083, Turkey

1 - MDP Algorithm for Wave Energy Conversion and Battery Storage

Trent Dillon, University of Washington, Seattle, WA, United States, tmaxd@uw.edu

We explore the application of a Markov Decision Process (MDP) algorithm to wave energy conversion and battery storage. Ocean waves are stochastic and intermittent. Wave power cannot be perfectly forecasted, and battery storage is necessary to overcome intermittencies. We developed an MDP algorithm that uses a stochastic wave forecast to make optimal operational decisions on power consumption versus storage. In simulation, we show that the incorporation of an MDP leads to more effective battery storage and power availability for autonomous wave-powered systems.

2 - The Optimisation of Public Sector Buildings Portfolio Energy Consumption

Paul McWilliams, Strategic Investment Board, Belfast, United Kingdom, pmcwilliams08@qub.ac.uk

A mathematic approach to develop dynamic building type energy reduction targets for the public sector building portfolio.

3 - Exploring the Effects of Persuasive Information on Local Residents Support for the Planning of Energy Facilities with Radioactive Hazard in China

Zhi Li, University of Science and Technology of China, hefei, China, 648893047@qq.com

Linking two routes of perceptible information from Elaboration Likelihood Model to different local residents' support level to the planning of energy facilities with radioactive hazard, we propose that local residents as direct stakeholders of energy facilities whose attitudes toward the project tend to rely on the positive central route information when faced with more self-interest signals from peripheral route, but rely on the negative central route information when faced with more false information. We provide empirical support for our theory by investigating the local residents' support level of large-scale energy facilities in China when those projects stay in planning phase.

4 - Ancilllary Market Designs to Incentivize Flexibility in Power Systems

Mort David Webster, Professor of Energy Engineering, Pennsylvania State University, University Park, PA, United States, mort@psu.edu

Generators that participate in electricity markets tend to get most of their revenue from energy and capacity markets. We demonstrate that this can create a disincentive to increasing some types of flexibility. We use a stochastic unit commitment model to explore how different ancillary service market designs can improve the incentives to owners to invest in operational flexibility, and compare the impacts of using an operating reserve demand curve and/or a flexi-ramp product.

5 - Impact of Psychological Factors on Energy-saving Behavior: Moderating Role of Government Subsidy Policy

Yi She, University of Science and Technology of China, Hefei, China, 599274427@qq.com

This paper studies the effect of government incentive measures and the moderating effect of psychological factors on the energy-saving behavior of Chinese residents. Results show that the energy-saving attitude and environmental responsibility of residents have a significant positive impact on energy-saving behavior, whereas consumer values have none. This result differs from the findings of previous studies. The subsidy policy has a vital role in promoting energy-saving behavior and a significant positive moderating effect on attitude and energy-saving behavior. However, it has a significant negative moderating effect on environmental responsibility and energy-saving behavior.

6 - Pathways to Carbon Neutrality for Turkish Energy System Using Leap and Osemosys

Emre Celebi, Assistant Professor, Kadir Has University, Istanbul, Turkey, ecelebi@khas.edu.tr, Gokhan Kirkil, Ahmet Deniz Yucekaya

This study compares two energy models, Long-range Energy Alternatives Planning (LEAP) and Open Source energy Modelling System (OSeMOSYS) for integrated assessment and energy planning of Turkish electricity system. We have studied three energy transition scenarios until 2050; the business as usual (BAU), energy conservation (EC) and renewable energy (REN) scenarios. EC scenario considers use of energy efficient appliances and imposing carbon tax, whereas REN scenario considers increasing the share of the renewables as much as possible in the power generation mix. We have evaluated these scenarios in terms of cost and environmental impacts and concluded that the REN scenario is the best option.

■ TD80

S- Issaquah B

Frontiers in Innovation

Sponsored: Technology, Innovation Management & Entrepreneurship

Sponsored Session

Chair: Gulru F Ozkan-Seely, University of Washington Bothell, Bothell, WA, 98011, United States

1 - Discovery vs. Repositioning: An Empirical Study of Time Allocation Contingencies in Drug Development

Moren Levesque, York University, Schulich School of Business, 4700 Keele Street, Toronto, ON, M3J 1P3, Canada, mlevesque@schulich.yorku.ca, Annapoornima Subramanian, Vareska Van De Vrande

The biotechnology and pharmaceutical industry employs two approaches in bringing drugs to market. The first is to engage in new drug discovery and development from scratch, while the second approach called drug repositioning, repurposes a previously approved and launched drug by identifying new therapeutic applications. Firms must give equal consideration to both approaches to maintain an effective and efficient drug portfolio. Drawing insights from the exploration-exploitation literature, our study formally models and empirically tests how firms operating in the industry can develop and maintain an optimal balance across the two approaches.

2 - Outsourcing and Offshoring in Complex Product Development Projects

Ole Frauen, Volkswagen AG, Brieffach 1853, Wolfsburg, 38436, Germany, Arnd H. Huchzermeier, Jurgen Mihm

Should a company outsource or offshore development? Globally operating organizations that develop complex products are faced with the question of how to efficiently decompose and allocate product development work across geographic, or organizational boundaries. The decisions must clearly depend on characteristics of the product (such as its architecture or its innovativeness). Based on an extensive data set involving all development projects of one of the largest car manufacturers worldwide, we study how different product characteristics affect the relationship between outsourcing and offshoring and product quality in complex product development.

3 - The Impact of Emission Policies on Technology Investment Decisions

Leonardo P. Santiago, Copenhagen Business School, Department of Operations Management, Solbjerg Plads 3, Blok B. 5. sal, Frederiksberg, Denmark, Franz Buchmann

We develop a model to investigate the investment decisions to cope with emission's target, which are subject to uncertainty stemming from economic and regulatory risks. The research is motivated by the case of the maritime industry. The results indicate that the optimal investment policy has to balance the trade-off between costs of installing technological measures today and expected future cost reductions through higher carbon efficiency. More importantly, the extent of the investment is increasing in the ship owner's current demand for pollution. Also, the optimal investment policy is significantly affected by the economic and regulatory risks and by the magnitude of their uncertainty.

4 - Knowledge-Based View of the Use of an Intermediary in New Product Manufacturing Outsourcing

Qiong Chen, University of Science and Technology of China, School of Management, University of Science and Technology of China, Hefei, 230026, China

We introduce a game-theoretic model to examine the impact of outsourcing knowledge, and firm- and market-level factors, on a buyer's decision of whether to employ an intermediary to identify a manufacturer for her new product. We find that indirect outsourcing is more attractive as the buyer's outsourcing knowledge increases but follows an inverse-U shape as that of the agent increases.

■ TD81

S- Kirkland

Stochastic Oilfield Optimization

Sponsored: Energy, Natural Res & the Environment/Natural Resources Petrochemicals

Sponsored Session

Chair: Atefeh Jahandideh, PhD, University of Southern California, CA, United States

1 - Stochastic Optimization Models for Short-term Oil Production

Thuener Silva, PUC-Rio LAMPS, Rio de Janeiro, Brazil, thuener@esp.puc-rio.br, Davi Valladao, Tito Homem-de-Mello, Bernardo Kulnig Pagnoncelli, Carlos Rodriguez, Bruno Vieira

The process of managing oil production on offshore platforms with multiple wells is complex. The decision maker has to deal with multiples production curves, platform constraints and the presence of uncertainties associated with oil production. Deterministic optimization models use the simulated points, along with binary variables, to express a piecewise linear proxy for the production curve. In this context, we propose a two-stage stochastic programming model that aims at obtaining the optimal target gas-lift injection and wellhead pressure under uncertainty, using a computationally tractable approximation of the production curves.

2 - Physics Embedded Machine Learning for Modeling and Optimization of Oil and Gas Assets

Pallav Sarma, Chief Scientist, Tachyus, Berkeley, CA, United States, Pallav@tachyus.com

This talk describes a unique modeling approach termed Data Physics. Data Physics is the amalgamation of the state-of-the-art in machine learning and the same underlying physics present in reservoir simulators. These models can be created as efficiently as machine learning models, integrate all kinds of data, and can be evaluated orders of magnitude faster than full scale simulation models. We present applications of Data Physics models to real steamflood and waterflood optimizations, wherein, the injectant is redistributed to maximize/minimize multiple objectives. A significant increase in actual incremental oil production and reduction in operational cost is demonstrated.

3 - Stochastic Optimization of Heavy Oil Reservoirs

Cenk Temizel

Please check the mobile app for this abstract.

4 - Well Location Optimization Using Reinforcement Learning

Kshitij Dawar, Graduate Research Assistant, The Pennsylvania State University, State College, PA, United States, Mort David Webster, Sanjay Srinivasan

A novel approach using Reinforcement Learning (RL) is developed to capture the uncertainties in petrophysical properties during reservoir development by developing several approximate solutions, in conjunction with existing geostatistical reservoir modeling techniques and Ensemble based Kalman Filtering, for developing reservoir models has been proposed. Seismic data along with well logs (to determine reservoir lithofacies) as they become available during the reservoir development process are utilized to suggest locations for future exploration. We demonstrate that the policies generated using RL outperforms a myopic policy of pure exploitation and improves future well exploration.

■ TD82

S- Leschi

Joint Session ENRE/Env/Practice Curated: Sustainable Energy Modeling and Practice

Sponsored: Energy, Natural Res & the Environment/Environment & Sustainability

Sponsored Session

Chair: Kristen Schell, Rensselaer Polytechnic Institute, Troy, NY, 12180, United States

1 - Spatio Temporal Wind Power Prediction with a Case Study in ERCOT

Mario E. Arrieta-Prieto, Rensselaer Polytechnic Institute, Troy, NY, United States, arriem2@rpi.edu, Kristen Schell

Spatio-temporal prediction of renewable power output is critical for optimizing its integration into the power system. Making accurate predictions in the space-time domain is a difficult task due to asymmetric and nonlinear relationships as well as potential bounded/censored observations. Previous models have addressed these issues separately, however, few models provide an integrated solution. This work combines a time-varying copula approach to model spatial interactions with cutting-edge temporal models to jointly address the probabilistic forecasting in the short run. The model is tested and validated on geographically diverse wind farm locations in the Texas power system of ERCOT.

2 - Transitioning Towards an Energy Efficient and Low Carbon Economy: A Review of Strategies Being Implemented in Ghana

Papa Yaw Owusu-Obeng, Rensselaer Polytechnic Institute, Troy, NY, United States, pyowusuobeng@gmail.com

The inadequacies of the electricity sector of Ghana have resulted in persistent load shedding over the last three decades. Ghana's power shortages are mainly caused by the increasing rate of domestic electricity demand which on average, accounts for 51% of total consumption and continues to rise sharply at a rate of 6% - 7% p.a. The prevailing situation has created the need to accelerate demand-side management strategies to curtail electricity demand growth. This work presents a review of nationwide programs implemented in Ghana to improve end-use efficiency and promote distributed renewable energy generation. The results demonstrate significant reductions in peak demand.

3 - Generalized Hourly Wind Power Prediction Model

Kristen Schell, Rensselaer Polytechnic Institute, Troy, NY, 12180, United States, schelk@rpi.edu, Andrea Staid, Seth Guikema

Decarbonization of the power sector is predicted to provide 50 percent of the greenhouse gas emission reductions needed to prevent global temperature rise above 2 degrees Celsius. Wind power installation is expected to be a major contributor to power system decarbonization, yet accurate models do not exist for long-term wind power prediction. We have developed a machine learning model of hourly wind power output that performs well across varied geographic terrain. The results are useful for power system planners and operators in designing and managing the renewable energy transition.

4 - Optimizing the Use of Curtailed Power in the Electric Grid

Ahmed Abdulla, Carnegie Mellon University, Pittsburgh, PA, 92093, United States, Kristen Schell

In the past decade, decreasing costs and government incentives have led to a forty-fold increase in installed solar capacity worldwide; installed wind capacity has increased six-fold over the same period. As a result, several major electricity markets have seen an increase in curtailment: the shutting down of production from renewable generators because the system cannot integrate it. This work assesses the risks of renewable power curtailment in California using an hourly, five-year historical record. We analyze how to transform these risks into benefits by powering technologies that could exploit curtailed generation and evaluate the likely cost and performance of each of these.

■ TD83

S- Medina

Power System Expansion Analysis

Sponsored: Energy, Natural Res & the Environment/Electricity

Sponsored Session

Chair: Enzo E Sauma, Pontificia Universidad Catolica de Chile, Santiago, Chile

1 - The Role of Expectations for Market Design – on Structural Regulatory Uncertainty in Electricity Markets

Harry van der Weijde, The University of Edinburgh, Edinburgh, 0, United Kingdom, H.Vanderweijde@ed.ac.uk
Harry van der Weijde, The Alan Turing Institute, London, United Kingdom, H.Vanderweijde@ed.ac.uk, Mirjam Ambrosius, Jonas Egerer, Veronika Grimm

Ongoing policy discussions on the reconfiguration of bidding zones in European electricity markets induce structural uncertainty about the future market design. This paper deals with the question of how this structural uncertainty affects market participants and their long-run investment decisions in generation and transmission capacity. We propose a stochastic multilevel model, which incorporates generation capacity investment, network expansion and redispatch, taking into account uncertainty about the future market design. Our results reveal that expectations about future market structures have an important effect on investment decisions.

2 - Long-term Planning Models on Steroids: Representation of Short-term Operation for Long-term Decision Making

David Pozo, PhD, Skolkovo Institute of Science and Technology, Moscow, Russian Federation, d.pozo@skoltech.ru

Long-term power system planning requires a representation of the many, possibly infinite, operational setpoints of the future states of the system. A couple of decades ago, Planners used a few aggregated values of system demand for incorporating into their optimization models. An avalanche of new models with an extensive representation of the operation has appeared with the same premise: clustering high-dimensional data into low-dimensional one (typical days or periods). In this presentation, we will describe the most common approaches, and we will propose an alternative for embedding an infinite-dimensional set of short-term operation into long-term planning models.

3 - Incorporating Cooperative Game Theory Principles into Cross-Border Transmission Expansion Planning Algorithms

Andrey Churkin, Skoltech, Moscow, Russian Federation, andrey.churkin@skolkovotech.ru, David Pozo, Enzo E. Sauma, Janusz Bialek, Nikolay Korgin

Cooperative game theory found an extensive application in power system studies. The particular interest lies in power systems interconnection projects where each system (or country) is an independent player who can accept the terms of cooperation or veto construction of interconnections. Various solution concepts such as the Shapley value and the Core have been exploited in order to share possible benefits of cooperation. However, all of the concepts were implemented as ex-post add-ins. We suggest a novel approach to cross-border transmission expansion planning that explicitly embeds cooperative game theory principles into the optimization and leads to more realistic solutions.

4 - Impact of Introducing Flexibility in Transmission Expansion Planning: An Application in the Chilean Power System

Enzo E. Sauma, Pontificia Universidad Catolica de Chile, Santiago, Chile, esauma@ing.puc.cl, Francisco Mariscal, Tomás Reyes

We study the value of adding flexibility to Transmission Expansion Planning (TEP) projects from the perspective of a social planner using real options. The existence of multiple sources of uncertainty often cause traditional project valuation methods to recommend sub-optimal investment decisions. To properly incorporate the effects of uncertainties on the valuation of TEP projects, we propose a methodology that values the net discounted social welfare of adding flexibility through real options, using Least Squares Monte Carlo. The methodology is applied to determine the value of adding flexibility to a portion of the project that connects the main two systems in Chile since 2018.

■ TD84

S- Ravenna A

Sustainable and Resilient Energy Systems

Sponsored: Energy, Natural Res & the Environment/Energy Sponsored Session

Chair: Roshanak Nateghi, Purdue, IN, 47907, United States

1 - Understanding the Regional Impacts of Climate Change on Natural Gas Sector with CGE Modeling

Duan Zhang, University of California Santa Cruz, Santa Cruz, CA, 95062, United States, dzhang33@ucsc.edu, Yihsu Chen

Exploring resilience options and adaptation measures to climate change impacts are becoming an important issue in regional planning. In order to implement the cost-effective resilience options, it’s important for the regional planner and policymakers to understand not only the local economic impacts of climate-change-induced hazards, but also the spillover effect to other sectors and regions. We studied the regional economic impacts of such hazards with a focus on California natural gas sector. A computable general equilibrium (CGE) model with bilateral trade flow was constructed to represent the impacts of gas service disruption.

2 - Modeling the Impact of Climate Change on the New York State Energy Consumption

Renee Obringer, Purdue University, West Lafayette, IN, United States, robringe@purdue.edu, Sayanti Mukherjee, Roshanak Nateghi

As the climate continues to change, current models for projecting future energy demand (i.e., electricity and natural gas) need to be revisited. The role of climate on the coupled electricity-natural gas nexus has been understudied. Moreover, given the interdependence within energy sectors, it is important to consider the demand co-variance across the sectors. Unlike previous studies, here we present a study that evaluates the impact of a wide array of climate factors on end-use energy consumption while accounting for the covariance across the electricity and natural gas demand of the residential, commercial and industrial sectors, using the state of New York as a case study.

3 - A Generalized Predictive Modeling Framework to Assess Climate Sensitivity of Peak Electricity Load

Sayanti Mukherjee, Assistant Professor, University at Buffalo (SUNY), 342 Bell Hall, North Campus, Buffalo, NY, 14260, United States, sayantim@buffalo.edu, Panteha Alipour, Roshanak Nateghi

Peak electricity load forecasting is an important area of research in electricity markets, and power systems planning and operation. Unanticipated climate-induced surges in peak load can lead to supply shortages causing frequent brownouts / blackouts, and large-scale socioeconomic impacts. In this research, we present a data-driven generalized predictive modeling framework to assess the climate sensitivity of daily peak load, using Texas as our case study. We found that maximum temperature and dew point are the two most important predictors of the climate-sensitive portion of daily peak load. Our model can also be used to make short-term predictions of the climate-sensitive daily peak load.

■ TD85

S- Ravenna B

Incorporating Equity and Justice Concerns in the Design of Energy Systems

Sponsored: Energy, Natural Res & the Environment/Energy Sponsored Session

Chair: Arvind Ravikumar, Harrisburg University, PA, United States

1 - How Do We Reconcile Priorities During the Energy Transition?

Emily Grubert, Georgia Institute of Technology, Atlanta, GA, United States, gruberte@gatech.edu

Energy systems are vast collections of infrastructure with local, landscape, and global implications associated with a wide variety of impacts. Climate change is a major driver of current efforts to transition the energy system, but it is neither the only issue, nor for many people, the most salient issue associated with energy system transition. Designing energy systems for equity and justice requires explicit consideration of both outcomes and processes, with attention to multiple value systems. This talk addresses some of those value systems and their implications.

2 - Energy Systems Impacts on Pollution, Environmental Health, and Environmental Justice

Amanda Giang, Assistant Professor, University of British Columbia, Vancouver, BC, Canada, amanda.giang@ubc.ca

Energy systems may have adverse impacts for human and community health and well-being, and these impacts have been found to disproportionately be borne by marginalized communities. In this talk, focusing on air pollution and toxic chemicals, we describe illustrative examples of distributive injustice for low-income, racialized, and Indigenous communities in North America, using geospatial, integrated modelling, and case study research methods. Finally, we discuss potential opportunities for environmental and energy systems modellers and impacted communities to work together to better integrate health, wellbeing, and justice concerns in energy systems planning.

3 - Planning with Justice: Using Spatial Modelling to Incorporate Justice in Electricity Pricing - The Case of Tanzania

Hisham Zerriffi, Associate Professor, University of British Columbia, Vancouver, BC, Canada, hisham.zerriffi@ubc.ca, Vikas Menghwani, Alexandros Korkovelos, Babak Khavari, Andreas Sahlberg, Mark Howells, Dimitris Mentis

SDG7 strives to ensure modern energy access for all. Diversification of electricity through expansion of off-grid or mini-grid solutions poses challenges for both affordability and fairness. We demonstrate a methodology to apply equality and equity principles of justice in quantitative electrification planning. We use an open source spatial electrification model to arrive at cost-recovery price levels for Tanzania based on principle(s) of justice. We then calculate location-specific subsidy levels needed to ensure those price levels. Through our analysis, we put forth a methodological framework to examine concerns around distributive justice using quantitative energy modelling tools.

4 - Social Impacts of Carbon-beneficial Forest Management in California

Daniel Sanchez, Assistant Cooperative Extension Specialist, University of California, Berkeley, Berkeley, CA, United States, sanchezd@berkeley.edu, Bodie Cabiyo, Jun Wong

Responsible stewardship of forests can address key challenges posed by climate change including carbon sequestration, producing low-carbon products, and reducing the risk of catastrophic wildfire. However, little is known about the distributional and equity impacts of expanded forest management across the State. Here, we quantify the social impacts of carbon-beneficial forest management. We accomplished this by examining the potential for innovative wood products to drive forest management across California. We develop several metrics for the social impact of expanded management, including real estate values, economically disadvantaged communities, and high risk to life and property.

■ TD86

S- Ravenna C

Advanced Manufacturing Control

Emerging Topic: Advanced Manufacturing

Emerging Topic Session

Chair: Changqing Cheng, Binghamton University, Binghamton, NY, 13902, United States

1 - Spatio-temporal Modeling for Tool Wear Propagation in Micro Friction Stir Welding

Weihong (Grace) Guo, Rutgers, The State University of New Jersey, Piscataway, NJ, 08854, United States, wg152@rutgers.edu, Zhe Gao

Solid state joining processes usually require a custom-made tool that rotates at high speed. When joining high-strength, lightweight materials, the tool condition is subject to severe strain, friction, and temperature. It is well acknowledged that tool wear affects joint quality. In this study, we develop a spatio-temporal model to characterize the dynamic tool wear propagation in micro-friction stir welding. The proposed model is developed in a hierarchical Bayesian structure with the first level being a data-driven regression model for the high-resolution tool pin profile and the second level being a physics-based advection-diffusion model for the latent (unobserved) welding temperature.

2 - Optimal Shape Control via L Infinity Loss for Large Space Structures

Juan Du, Oregon State University, College of Engineering, Corvallis, WA, 100871, United States, Shanshan Cao, Xiaoming Huao, Jianjun Shi

Natural dimensional variabilities of incoming large structures affect the assembly speed and quality of joins in large space structure assembly process. Thus, shape control is critical to ensure the quality of assembly. This paper proposes an optimal shape control methodology based on l infinity loss for large structure assembly process by considering the initial dimensional gap between the incoming pair of structures. Some related theoretical properties are shown. Compared to the current practice, the case study shows that our proposed method significantly reduces the maximum gap between two structures after shape adjustments.

3 - Decentralized Learning Enabled Control for Streaming Data in Distributed Manufacturing Agents

Hongyue Sun, University at Buffalo, Industrial and Systems Engineering, Buffalo, NY, 14260, United States, hongyues@buffalo.edu, Xinran Shi, Yi Zhou

Many manufacturing agents are being connected due to the advancement of information and sensing technology. However, most existing modeling and control methods are designed for individual agents. We propose a Decentralized Learning enabled Control (DLC) scheme for streaming data in distributed agents. In the proposed scheme, we dynamically learn the neighborhood of an agent to be controlled as new data stream in. Then, Decentralized Communication Sliding (DCS) algorithm is used for process modeling and control based on the agent's neighborhood information. We demonstrate the proposed DLC scheme in distributed agents in a crystal growth process.

■ TD88

S- Cedar A

Health Care, Public Health I

Contributed Session

Chair: Karen Angulo, Universidad de los Andes, Bogotá, 110111, Colombia

1 - Will Organizational Change Improve Healthcare Service Efficiency? A Natural Experiment Study Says Yes

Ai Ren, University of Maryland-College Park, Robert H. Smith School of Business, College Park, MD, 20740, United States, renai@rhsmith.umd.edu, Qi Li, Liye Ma

We studied a natural experiment in the largest cancer specialized hospital in the northern China. After introducing a new group of physicians to the hospital, the existing physicians group changed their behavior by ordering more tests and exams but at lower total cost. The overall healthcare outcomes were also improved.

2 - Global Budget Revenue Policy Impact on Emergency Department Efficiency in Maryland

Ai Ren, University of Maryland-College Park, Robert H. Smith School of Business, College Park, MD, 20740, United States, renai@rhsmith.umd.edu, Bruce L. Golden, Edward Andrew Wasil, Frank B. Alt, Margrét Bjarnadóttir, Jon Mark Hirshon, Laura Pimentel

We conduct an empirical analysis of the impact of Global Budget Revenue (GBR) implementation on Emergency Department (ED) efficiency measures for inpatients from January 2014 to April 2016 in Maryland. We use public data from the Centers for Medicare and Medicaid Services, the Census Bureau, and the Kaiser Family Foundation. Our study uses the difference-in-difference model with mixed effect. We find GBR has a statistically significant negative impact on Maryland ED efficiency performance for inpatients.

3 - Dta-driven Decision Support System for Assessment of Tertiary Healthcare Facilities

Zainul Abidin, LUMS University, Lahore, Pakistan, zain.khawaja@lums.edu.pk, Adeel Zaffar, Khudeja Ali, Fareed Zaffar

Development spending in third world countries is scarce and we need to identify conduits and targets that have the maximum potential for impact. This translates to channeling development funds into the most efficient public health care facilities. Unfortunately no system exists for a comparative assessment of such facilities to identify the most deserving targets. We present a data-fed ranking system for tertiary health facilities, that takes into account metrics like footfall, patient/doctor ratio, equipment efficiency, unplanned overheads, chain of referral etc, creating a weighted ranking that identifies which facilities can have the highest impact with incoming development funds.

4 - Improving Physical Activity Measurements with Data Analytics

María A. Wilches-Mogollon, Universidad de los Andes, Bogotá, Colombia, ma.wilches529@uniandes.edu.co, Olga L. Sarmiento

Accelerometers are able to capture the intensity of physical activity (PA) by measuring acceleration along the 3 movement axes. In health studies that measure PA, a typical valid sample consists of data collected for more than 10 hours over 4 consecutive days for a given participant. Yet, the relatively low adherence rates to accelerometers often threaten the sample size. A typical valid rate reaches up to 50% of the total collected data. To increase the number of valid samples, we developed a data protocol that creates synthetic weeks and selects the best data for each participant using data analytics. We calibrated our model using 300 accelerometer measurements. The valid sample size increased by 20%.

5 - Advancing Equity in the Mental Healthcare Supply Chain: Empirical Evaluation of a Mobile App

Yi Tang, Carlson School of Management, Minneapolis, MN, United States, tangx688@umn.edu, Kingshuk K. Sinha, Adam Moen

We empirically investigate user usage behavior of a mental health mobile app which consists of a self-monitoring function and an anonymous online community and its impact on users' mental wellbeing conditions. The results indicate that mobile apps can create capacity in a mental healthcare supply chain so as to reduce the disparities associated with gender, sexual orientation, and ethnicity. Specifically, traditionally underserved populations in the mental healthcare supply chain access and benefit from the mental health mobile app indifferent from or more than their better-served counterparts.

6 - Risk of Autoimmune, Neurological and Thromboembolic Diseases Due to Human Papilloma Virus Vaccination in Colombia

Karen Daniela Angulo, Universidad de los Andes, Bogotá, Colombia, kd.angulo2295@uniandes.edu.co, Ivan Mura

Cervical Cancer is the second leading cause of cancer-related deaths in Colombia. Although there are vaccines that protect against high risk HPV strains, questions about whether such vaccines increase the risk of autoimmune diseases have contributed to low percentage of immunization coverage in Colombia. This study aims to epidemiologically evaluate and analyze if the incidence of autoimmune, neurological, and thromboembolic diseases is associated with HPV vaccination. We use nationwide databases for a case-control study. Cases were matched by sociodemographic characteristics. Risk differences were studied using generalized equations estimation and multivariate logistic regression.

■ TD89

S- Cedar B

Quantitative Risk Management

Sponsored: Finance

Sponsored Session

Chair: Ruodu Wang, ON, Canada

1 - Optimal Insurance Design with a Variance Constraint on the Ceded Loss

Shengchao Zhuang, University of Nebraska Lincoln, Lincoln, NE, United States, szhuang3@unl.edu, Yichun Chi, Xunyu Zhou

We study an optimal insurance design from the perspective of the insured, who maximizes the expected utility of the final wealth when an upper limit is imposed by the insurer on the variance of the risk exposure. We show that the optimal insurance policy is in the form of stop-loss for a high boundary value or partial insurance above a deductible for a low boundary value. Especially, the deductible disappears if and only if the safety loading coefficient is zero. Through a comparative analysis, the effect of the insured's initial wealth and upper limit of the variance of the insurer's risk exposure on the insurance demand is then examined, when the insured's risk aversion and prudence are taken into account.

2 - Smart Order Routing via Machine Learning

Renyuan Xu, University of California-Berkeley, Berkeley, CA, 94720, United States, dorisxu1026@gmail.com
Renyuan Xu, University of Oxford, Oxford, United Kingdom, dorisxu1026@gmail.com, Robert Almgren

Cash treasuries, unlike most of the financial products, are available to trade on multiple venues. As a result, cash treasuries market allows traders to be opportunistic with respect to where to place the orders.

In this talk, we formulate this decision-making problem as an optimization problem. We then construct an ensemble model with four machine learning methods to predict the order fulfillment on different venues. These methods are logistic regression, neural networks, random forests and gradient-boosting. We then design a parameterized trading algorithm based on the ensemble model to route limit orders in real time. Our algorithm shows superior performance compared with existing methods.

3 - Robust Distortion Risk Measures

Silvana M. Pesenti, University of Toronto, Toronto, ON, Canada, Carole Bernard, Steven Vanduffel

In the presence of distributional uncertainty, robustness of risk measures is crucial, and can be accounted for by providing bounds on the values of the risk measure, so-called worst- and best-case risk measures. Worst-case risk measures that only take the knowledge of the first moments of the distribution in consideration are, however, too large to be practically relevant. In this paper, we provide sharp bounds for the class of distortion risk measures with constraints on the first two moments combined with a constraint on the Wasserstein distance to a baseline distribution. Adding the Wasserstein distance, leads to significantly improved bounds and more realistic worst-case distributions.

4 - An Axiomatic Foundation of Expected Shortfall

Ruodu Wang, University of Waterloo, Waterloo, ON, N2L 3G1, Canada, wang@uwaterloo.ca

The Value-at-Risk (VaR) and the Expected Shortfall (ES) are the two most popular risk measures used in banking and insurance regulation. According to the recent Basel Accords, ES replaces VaR as the standard risk measure for market risk in the banking sector. The class of VaR has been characterized in the literature with several different sets of economic axioms, whereas the class of ES, although being coherent risk measures, does not have an axiomatic foundation yet. We propose four simple and intuitive economic axioms to uniquely characterize an ES. Our results provide the economic foundation for using ES as the globally dominating regulatory risk measure currently employed in Basel III/IV.

■ TD90

S- Redwood A

Logistics II

Contributed Session

Chair: Matthieu Gruson, HEC Montréal, Montréal, QC, H2E 1W8, Canada

1 - A Benders Decomposition Approach for Biomass Feedstock Logistics with Mobile Equipment

Fangzhou Sun, Virginia Tech, Blacksburg, VA, United States, fangzhou@vt.edu, Subhash C. Sarin

We address the optimal design and operation of a biomass feedstock logistics supply chain (BFLSC) where sharing of some equipment in the supply chain is allowed. The BFLSC problem is a combination of facility location problem, single-item capacitated lot-sizing problem, and vehicle routing problem. We formulate this problem as a mixed-integer program (MIP) and propose an efficient Benders decomposition-based solution method. Computational investigation reveals the advantage of the proposed method over a direct application of MIP solver. Our case study has shown substantial cost reduction due to mobilization.

2 - A Heuristic Approach to Solve the Multi-Node Replenishment Problem in the Fast Food Supply Chain

Alejandro Vigo Camargo, University of Michigan, Ann Arbor, MI, United States, avigo@umich.edu, Yavuz A. Bozer

Per the USDA, in 2017, consumers spent over $310 billion at fast food stores. Given the size of this segment, there is a surprising scarcity of work focused on the logistics of fast food supply chains. This study focuses on replenishing multiple stores in a fast food network. We present a heuristic to optimize the multi-store, multi-period replenishment problem, by minimizing the distance traveled and the number of trucks needed. Preliminary results using industry data show that the heuristic generally provides good solutions compared to those used by our industrial collaborator.

3 - Warehouse Outsourcing Decisions for Green Supply Chain Management

Chen Yu, The University of Hong Kong, Hong Kong, yuchenhku@gmail.com

The research proposes a model that adds warehouse outsourcing decisions to a green supply chain via mixed linear programming technique to give suggestions on whether and to what extent should a company use third party warehouses. Carbon footprint is analyzed in the model to facilitate a lower carbon emission supply chain under carbon taxing policy and carbon trading system.

4 - Closing the Gap Between Research and Practice in Manual Order Picking: State-of-the-art Classification and Review

Sarah Vanheusden, UHasselt, Hasselt, Belgium, sarah.vanheusden@uhasselt.be, Teun van Gils, Katrien Ramaekers

Research on planning problems in manual order picking is extensive. However, practical applicability of the developed algorithms is rather limited due to a lack of incorporation of practical issues (e.g., safety issues, human characteristics) within these models. A state-of-the art classification and review of order picking literature is performed in order to identify and analyse practical considerations in order picking operations. Future research opportunities are provided to support the development of practically relevant decision support models.

5 - Benders Decomposition for a Two-stage Three-level Lot Sizing and Replenishment Problem

Matthieu Gruson, HEC Montréal, Montréal, QC, Canada, matthieu.gruson@hec.ca, Jean-François Cordeau, Raf Jans

We address a stochastic and uncapacitated three-level lot sizing and replenishment problem with a distribution structure. We consider one production plant that produces one type of item over a discrete and finite planning horizon. The items produced are transported to warehouses and then to retailers using direct shipments. We develop a Benders-based branch-and-cut algorithm to efficiently solve the problem. We propose computational enhancements. In particular, we design an algorithm to derive Pareto-optimal cuts without solving an auxiliary problem. The algorithm we propose outperforms CPLEX.

■ TD91

S- Redwood B

Using Predictive Modeling to Improve Hospital Operations

Sponsored: Manufacturing & Service Oper. Mgmt/Healthcare Operations

Sponsored Session

Chair: Song-Hee Kim, University of Southern California, Los Angeles, CA, 90089, United States

1 - Adventures in Personalized Predictive Modeling in Healthcare

Edieal J. Pinker, Yale School of Management, Yale University, New Haven, CT, 06520, United States, Junchao Ma

Attempts to use machine learning techniques to create personalized predictions in healthcare are becoming common. Adoption of such methods in practice will require integrating them into the decisionmaking processes of physicians. We will discuss how accuracy of predictions should be reported and how the usefulness of these methods should be assessed.

2 - Timing it Right: Balancing Inpatient Congestion Versus Readmission Risk at Discharge

Pengyi Shi, Purdue University, West Lafayette, IN, 47907, United States, shi178@purdue.edu, Jonathan Helm, Jivan Deglise-Hawkinson, Julian Pan

When to discharge a patient plays an important role in hospital patient flow management as well as quality of care and patient outcomes. We develop and implement a practical decision support tool to aid hospitals in managing the delicate balance between individual readmission risk and ward congestion. Our framework integrates an individualized prediction model that updates the readmission risk over a patient's hospital stay with a large-scale Markov Decision Process (MDP) to optimize the day-to-day discharge decisions. We overcome challenges in the prediction and the curse of dimensionality in solving the MDP. Lastly, we discuss on-going implementation efforts of this discharge tool.

3 - Dynamic Prediction of Length-of-stay in the Neonatal Intensive Care Unit

Kanix Wang, University of Chicago, Booth School of Business, Chicago, IL, 60637, United States, Kanix.Wang@chicagobooth.edu, Walid Hussain, John R. Birge, Michael D. Schreiber, Daniel Adelman

The widespread implementation of electronic medical record (EMR) systems has enabled hospitals to collect massive amounts of health data. We propose a framework grounded in established clinical knowledge to model patients' LOS using EMR data. In particular, we impose expert knowledge when grouping raw clinical data into medically meaningful variables. We use dynamic predictive models to output patients' remaining lengths of stay, future discharges, and census probability distributions. Evaluated with large-scale EMR data, the dynamic model significantly improves predictive power over the performance of any model in previous literature and remains medically interpretable.

■ TD93

S- Grand Ballroom B

Operations/Economics Interface

Contributed Session

Chair: Seyedmohsen Hosseini, University of Southern Mississippi

1 - Combining Leximax Fairness and Utilitarianism in a Mathematical Programming Model

Violet Xinying Chen, Carnegie Mellon University, Pittsburgh, PA, United States, xinyingc@andrew.cmu.edu, John Hooker

We study the problem of combining equity and efficiency in optimization models. Previous work defined social welfare functions combining Rawlsian maximin fairness and utilitarianism with a single parameter, which measures the utility disparity allowed before utilitarian objective takes over fairness objective. We propose a vector-valued social welfare function combining Rawlsian leximax fairness and utilitarianism. Optimization of the vector-valued function requires a sequential procedure, where the problem in each iteration has a MILP formulation. Besides methodological exploration, we show that proposed social welfare function satisfies a weaker form of Pigou-Dalton condition.

2 - Relational Contracts with Prediction

Parinaz Naghizadeh, Ohio State Univeristy, Columbus, OH, United States, Thanh Nguyen, Shai Vardi

We consider supplier-retailer long term relationships sustained through relational incentive contracts. We evaluate the effects of availability of predictions of future production values to retailers and/or suppliers on the contracts. Specifically, a retailer can choose to fire their currently contracted supplier if they predict that next stage production value is low. We show that prediction undermines the ability of the parties to commit to long-term relationships. In particular, compared to the case where such forecasts are not available and cannot be used in the contracts, prediction may benefit the retailer but lowers product quality.

3 - Inventory Risk Management in Supply Chain: Pricing and Contracts

Houcai Shen, Nanjing University, Nanjing, China, hcshen@nju.edu.cn, Weili Xue

In this paper, we consider a supply chain in which a supplier produces and sells a single product to an independent retailer who faces price-dependent stochastic demand. The contracting strategy can be chosen between pull contract or push contract. The retail pricing strategy, on the other hand, can be chosen between committed pricing or responsive pricing. We show the effect of different combinations of contracting and pricing strategies on the operational decisions of the supply chain parties, and the supply chain parties' preferences.

4 - The Impact of Supply Chain Complexity on a Plant's Recovery Time

Laharish Guntuka, University of Maryland-College Park, College Park, MD, United States, lguntuka@rhsmith.umd.edu, Thomas Corsi, David E. Cantor

We investigate how the three dimensions of supply chain complexity: upstream, internal and downstream can impact a plant's recovery time from a supply chain disruption. In addition, we study how exogenous vulnerability risks, revenue at risk and the plant characteristics can moderate this relationship.

5 - Ripple Effect Analysis of Supply Chains Using Probabilistic Graphical Models

Seyedmohsen Hosseini, University of Southern Mississippi, Long Beach, MS, United States

Supply chain disruptions are increasingly caused by growing global supply sourcing, complexity, and interconnectedness of supply chains. A key challenge in the context of supply chain disruption management is how to model and simulate the ripple effect of SCs. The ripple effects occur when the impact of disruption on upstream cannot be harnessed or controlled and propagates downstream. This work presents a probabilistic graphical approach that formulates and simulate the ripple effect in SCs.

■ TD94

S- Grand Ballroom C

Risk Analysis II

Contributed Session

Chair: Chao Guo, Tongji University

1 - Developing Risk Analysis Tools for Capacity-constrained Networks

Sinan Tas, Assistant Professor, University of Wisconsin-Platteville, Platteville, WI, United States, tass@uwplatt.edu

This simulation model is used to create a risk framework so that the likelihood of failure of a component, such as attack, cascade, random failures, together with the impact due to failure can be analyzed in order to prioritize and visualize critical components of the network based on various attack and failure scenarios, and decide how to allocate defensive investments accordingly. We use IEEE 118- and 300-bus power flow systems to test our framework and compare the results.

2 - Risk Analysis as a Critical Tool to Combat Human Trafficking

Julia Coxen, University of Michigan, Ann Arbor, MI, United States, juliaoh@umich.edu

Human trafficking is a global crisis that continues to be difficult to detect, prosecute, and examine. Although human trafficking manifests in all forms of modern slavery, this paper will specifically examine the sexual exploitation component of human trafficking. We show that risk analysis is a critical tool in combating human trafficking and introduce current policy levers emplaced globally. We make comparisons with Terrorism Risk Analysis and establish lessons learned from intelligent adversarial analysis that can help policymakers unpack the complexities of this criminal enterprise.

3 - A Continuous Time Markov Decision Process to Increase Resilience in Physical Systems

Weimar Ardila, PhD Student, University of South Florida, Tampa, FL, United States, weimar@mail.usf.edu, Daniel Romero, Alex Savachkin, Devashish Das

Given the occurrence of a disruption event the idea of building a resilient system makes sense, however many actions that can increase resilience conflict with traditional business goals such as reducing costs and increasing operational efficiency, which makes the implementation of such actions a really complicated task if there is no a trade off between being resilient and the costs of being resilient. The main research objective is to propose an initial approach for a Markov Decision Process formulation focused on minimizing the cost related to the implementation of actions to reduce a system's total recovery time, under the framework of a multi-stage recovery process.

4 - A Resilience Assessment Framework for Metro Systems Considering Multitype Failures

Yue Gao, The University of Hong Kong, Hong Kong, yuegao@hku.hk, Junwei Wang

Unforeseen failures in metro systems may cause catastrophic impacts on their structure and functionality. Research on the resilience, i.e., the ability to recover from disruptions—is thus essential considering the safety of metro systems. However, no studies have analysed resilience considering different combinations of platform-based and track-based failures. To address this issue, this research established a novel resilience assessment approach with application in Hangzhou metro system. The results assist companies in planning a more resilient metro system by constructing more turning lines and reconfiguring a less concentrated passenger demand distribution.

5 - Do CEO Personality Traits Introduce Risk Into Firms?

Tiange WANG, PhD Candidate, Tsinghua University, Beijing, China

As top manager, CEO directly lead the firm's development. Plenty of studies have focused on CEO characteristics' impact on firm policies. However, these poicies and consequences are more related with CEO capability, performance and compensation. So, we argue that CEO personality traits are a critical factor on firm risk, which is almost unrelated with the compensation and is more likely to reflect the impact of personality. However, it is unpractical to gather information about CEO psychology. In this study, the Big Five theory is employed to describe CEO personality traits through their posts on Twitter. We try to investigate whether specific personality trait is related with firm risk.

6 - Quality Risk Evaluation of Aircraft Development under Main Manufacturer – Suppliers Mode Based on Flight Test Engineer View

Chao Guo, Tongji University, Shanghai, China, gcdzq@163.com and Commercial Aircraft Corporation of China LTD, Shanghai, China, gcdzq@163.com, Jianxin You, Xiaoyue You, Youxiang Cui

The "Main manufacturer - Supplier" model of the aircraft development introduces multiple risks into the flight test. By using the analytic hierarchy process, the readiness evaluation of flight test aircrafts was decomposed into eight evaluation indexes. Based on flight test engineers' view, the risk distribution of the main manufacturer and the suppliers was measured, and the main risk factor was selected.

■ TD95

S- Grand Ballroom D

Academic Job Search Panel

Sponsored: Minority Issues

Sponsored Session

Chair: Trilce Encarnacion, Rensselaer Polytechnic Institute, Troy, NY, 12180, United States

Moderator

Trilce Encarnacion, Rensselaer Polytechnic Institute, 110 8th Street, Jonsson Engineering Center # 4049, Troy, NY, 12180, United States

Panelists

- Clara Novoa, Texas State University, San Marcos, TX, 78666, United States
- Lewis Ntaimo, Texas A&M University, College Station, TX, 77843, United States
- Mingzhou Jin, Professor, University of Tennessee-Knoxville, Knoxville, TN, 37996, United States, jin@utk.edu

■ TD96

S- Willow A

Data Mining III

Contributed Session

Chair: Mehmet Yildirim, Binghamton University, Binghamton, NY, 13905, United States

1 - Multi-channel Attribution: A Survive Analysis Based Approach

Aslan Lotfi, Iowa State University, Ames, IA, United States, alotfi@iastate.edu, Xinxue Qu, Zhengrui Jiang

Using the survival analysis methodology, we study digital advertising channel attribution. Our data records customer exposures to ads for a video game through different digital advertising channels and corresponding conversions. We study how consumers' exposures to online ads through different channels affect their probability and timing of conversion as well as how an exposure's effect changes over time. Our results show that the effects of exposures do vary significantly across channels and that the maximum effect of an exposure may not be achieved at the time of its occurrence.

2 - Weibull Racing Time-to-event Modeling and Analysis of Online Borrowers' Loan Repaying and Default

Quan Zhang, PhD Candidate, University of Texas at Austin, Austin, TX, United States, quan.zhang@mccombs.utexas.edu, Qiang Gao, Mingfeng Lin

p { margin-bottom: 0.1in; line-height: 115%; } p { margin-bottom: 0.1in; line-height: 115%; } We propose Weibull racing (WR) to model the mechanism of time to competing events and to interpret how features accelerate or decelerate the time. WR explains potential non-monotonic feature effects data-adaptively, resulting in a good way for data mining. Furthermore, we use WR on an online peer-to-peer lending dataset from Prosper and analyze how borrowers' loan repaying and defaults are affected by features. We found features that reduce the hazard of borrowers' default may also accelerate their loan pay-off, leading to a trade-off between low risk and low return of investment for lenders.

3 - Anomaly Detection and Prediction for Multiple Channel Multi-time Series Data in Military Vehicle Reliability System

Morteza Alizadeh, Graduate Research Assistant, Mississippi State University, Starkville, MS, United States, ma1845@msstate.edu, Junfeng Ma

We develop a multivariate autoregressive model to predict temporal anomalies in a real-case multiple time series data channels. This model aims to detect contextual outliers based on deviations of time-stamps values from predictions. Individual time-stamp value at each channel is predicted as a linear function of immediately preceding window of last p time-stamps values in all channels. Proposed model leverages both successive correlations of time series data at each channel and other channels to predict each time stamp value. Large absolute values of deviations exhibit anomalies of channels. Obtained results verifies the capability of the proposed model.

4 - Online Non-linear Feature Imputation for Predictive Models in Healthcare

Sadaf Kabir, West Virginia University, Morgantown, WV, United States, Leily Farrokhvar

Accurate disease diagnosis and prediction of patient outcomes can improve hospital performance, optimize resources allocation, and reduce costs and time of patient care. In this study, we propose a non-linear feature imputation method to estimate the missing patient related data. The estimated values are then used to provide more accurate predictions for patient outcomes.

5 - An Entropy Based Novel Feature Selection Algorithm for Clustering a Healthcare Dataset

Mehmet F. Yildirim, PhD Candidate, Binghamton University, Binghamton, NY, United States, myildir3@binghamton.edu

Different feature subsets could lead to different clusters in a large and high-dimensional dataset. However, a true clustering result may not be chosen among many possible options for a correct interpretation of the dataset. One of the viable solutions is to choose the best feature subset for clustering which would lead to better understanding and processing of the dataset as well as expedite the clustering algorithm. For this purpose, an entropy-based feature selection algorithm is proposed to cluster a healthcare dataset where the redundant features are removed to make the clustering algorithm robust. The clustering result is evaluated using two different performance criteria.

■ TD97

S- Willow B

Supply Chain Optimization II

Contributed Session

Chair: Seyed Ali Haji Esmaeili, North Dakota State University, Fargo, ND, 58102, United States

1 - Designing Distribution Networks for Low-demand Items with Given Delivery Time Targets

Geert-Jan Van Houtum, Eindhoven University of Technology, Eindhoven, Netherlands, g.j.v.houtum@tue.nl, Ahmadreza Marandi

We look at the design of a distribution network for multiple low-demand items with stochastic single-unit demand processes (e.g., spare parts). Demands from geographically dispersed customers have to be satisfied within given delivery time targets. Local warehouses can be chosen from a given set of candidate locations. We include in our design that, at the executional level, a given demand can be satisfied from multiple chosen local warehouses. We follow a robust optimization approach.

2 - Additive Manufacturing Spare Parts Supply Chain with Repair Decisions

Brett A. Shields, Assistant Professor, Francis Marion University, Florence, SC, United States, bshields@fmarion.edu, Dante Ahquin

Strategic decisions in spare-parts supply chains have significant implications within the supply chain configuration. In this research, additive manufacturing machine procurement, make-or-buy, and repair decisions for critical spare parts are considered. A mixed-integer linear programming model is formulated to minimize the cost of satisfying critical spare parts demand over a long-term planning horizon. The presented methodology provides a solution for spare-parts supply chains where repairing parts is viable through additive manufacturing, without the limitations of the current models.

3 - Stochastic Model for Optimizing Transparency and Traceability in Food Supply Chain

Meghna Maity, Kansas State University, Manhattan, KS, United States, mmaity@ksu.edu

Absence of food transparency and traceability has led to severe problems like product recall, consumer dissatisfaction, and contamination insecurities in the past. These issues escalate with demand uncertainty. We overcome traceability in food supply chain by developing a stochastic batch dispersion model that integrates an emerging blockchain technology to provide insight in supply chain transparency.

4 - Supply Chain Finance with Smart Contract

Jing Luo, University of Pittsburgh, Pittsburgh, PA, United States, JIL204@pitt.edu

Blockchain receives great popularty in recent year. We summarize the unique features of smart contract from blockchain and apply this new technique in supply chain finance to improve the working capital of SME.

5 - An Optimization Approach to the Market Incentive Analysis of Second-generation Bioethanol Supply Chains

Seyed Ali Haji Esmaeili, North Dakota State University, Fargo, ND, United States, ali.hajiesmaeili@ndsu.edu, Joseph Szmerekovsky, Ahmad Sobhani

First-generation bioethanol produced from food-based biomass has been produced globally which has increased new social issues such as the food versus fuel debate. Thus, this study promotes second-generation bioethanol which is produced from non-edible biomass feedstocks by considering monetary incentives. This incentive policy would be offered to already-existing first-generation bioethanol producers only if they change their production technology to second-generation. To analyze the impacts of incentives, first-generation and second-generation bioethanol supply chains are compared.

Tuesday, 3:40PM - 4:30PM

■ Keynote

CC- Room 6E

Keynote: Learning Personalized Policies: Theory and Applications

Emerging Topic: Keynote

1 - Learning Personalized Policies: Theory and Applications

Susan Athey, Stanford University, 655 Knight Way, Stanford, CA, 94305, United States

An important application of machine learning concerns the problem of learning treatment assignment policies that assign the optimal treatment to individuals as a function of their observable characteristics. This talk will review recent developments in offline policy learning and hypothesis testing, whereby historical data is used to estimate optimal policies accounting for the fact that personalization and adaptive experimentation or bandits were used in historical treatment assignments. A variety of empirical applications will be presented, including applications for personalized pricing, contextual bandit experiments, and targeted government policies.

■ Keynote

CC- Room 6C

Keynote: Predictive Data Science for Physical Systems: From Physics-based Models to Scientific Machine Learning

Emerging Topic: Keynote

1 - Predictive Data Science for Physical Systems: From Physics-based Models to Scientific Machine Learning

Karen Willcox, University of Texas at Austin, Austin, TX, United States

For high-consequence decisions in science, engineering and medicine—big decisions—we need more than just big data, we need big models too. These problems are characterized by complex multi-scale multi-physics dynamics, where small changes in parameters can lead to drastic changes in system behavior. They are also typically characterized by high-dimensional uncertain parameters that cannot be observed directly, and by a need to issue predictions that go well beyond the specific conditions where data may be available. For these reasons, a purely data-focused perspective will fall short. Achieving predictive data science for these complex physical systems requires a synergistic combination of data and physics-based models. Learning from data through the lens of models is a way to bring structure to an otherwise intractable problem: it is a way to respect physical constraints, to embed domain knowledge, to bring interpretability to results, and to endow the resulting predictions with quantified uncertainties. As one example, this talk shows how formulations from projection-based model reduction can be combined with machine learning methods to achieve this. Case studies in aerospace engineering applications demonstrate the importance of embedding physical constraints within learned models, and also highlight the important point that the amount of model training data available in an engineering setting is often much less than it is in other machine learning applications, making it essential to incorporate knowledge from physical models.

■ Keynote

CC- Room 6B

Keynote: Protecting Community Waterways: Applying Analytics and Optimization for Wastewater Management (Edelman Reprise)

Emerging Topic: Keynote

1 - Protecting Community Waterways: Applying Analytics and Optimization for Wastewater Management

Angela Akridge, Louisville MSD, Louisville, KY, United States, Wolffie Miller, Diana Qing Tao

The Louisville and Jefferson County Metropolitan Sewer District (Louisville MSD) in Kentucky, USA, uses operations research, advanced analytics and innovative engineering concepts to protect local community waterways by optimizing the collection, transport and treatment of wastewater. In partnership with Tetra Tech, Louisville MSD pioneered the application of real time control using Csoft®, which relies on sewer monitoring data, weather forecasting, and data analytics for system-wide optimization. In operation since 2006, the solution has reduced more than 2 billion gallons of sewer overflows per typical year and saved the community over $200 million of capital cost.

■ Keynote

CC- Room 6A

Keynote: Wagner Prize Winner

Emerging Topic: Daniel H. Wagner Competition

The Daniel H. Wagner Prize is awarded for a paper and presentation that describe a real-world, successful application of operations research or advanced analytics. The prize criteria emphasize innovative, elegant mathematical modeling and clear exposition.

Tuesday, 4:35PM - 6:05PM

■ TE01

CC- Room 201

Interpretable Predictive Models

Sponsored: Data Mining

Sponsored Session

Chair: Ozge Surer, Northwestern University, Evanston, IL, United States

1 - Actionable Recourse in Linear Classification

Berk Ustun, Harvard University, Cambridge, MA, United States, berk@seas.harvard.edu, Alexander Spangher, Yang Liu

In machine learning, recourse refers to the ability of a person to change the decision of a model by altering actionable input variables (e.g., income rather than age). We present integer programming tools to check recourse in linear classifiers. Given a classifier, our tools can (1) measure the feasibility and difficulty of recourse in a population of interest and (2) list actions for a person to obtain a desired outcome from a classifier. We demonstrate how our tools can inform key stakeholders in credit scoring, and discuss why we should evaluate recourse in automated decision-making.

2 - Model-Agnostic Linear Substitutes for Black-box Machine Learning Models

Tong Wang, University of Iowa, Pappajohn Business Build, Iowa City, IA, 52245, United States, tong-wang@uiowa.edu, Qihang Lin, Rafique Hassan

This work proposed a novel framework that builds hybrid models which combine interpretable models with a black-box model. A hybrid model builds linear models to substitute a provided black-box model on a subset of data where the black box is overkill to gain partial transparency while leaving the rest to the black-box model. With various parameter setting, the hybrid model gains an efficient trade-off between transparency and accuracy. The proposed model applies to multiclass classification and can solve structured data and text data. It provides more model choices for users and unify interpretable models and black-box models into the same framework.

3 - Joint Learning of Prototypes and Decision Boundary for Multiple Instance Learning Problems

Mustafa Gokce Baydogan, Assistant Professor, Bogazici University, Istanbul, Turkey, mustafa.baydogan@boun.edu.tr, Ozgur Emre Sivrikaya, Mert Yuksekgonul

In Multiple Instance Learning (MIL), each bag can be represented with their distances (or dissimilarities) to certain prototypes in dissimilarity space. These prototypes are important for interpretability in some tasks. Learning algorithm developed in this work jointly learns prototypes in the feature space and logistic regression classifier that minimizes logistic loss of misclassification. Our experimental results show that proposed approach works well on common MIL data sets from diverse domains.

4 - Interpretable Machine Learning: Models and Applications

Xia Ben Hu, Assistant Professor, Texas A&M University, Computer Science and Engineering, 330B HRBB, College Station, TX, 77843, United States, hu@cse.tamu.edu

This talk will cover the recent progress of ongoing efforts directed by Dr. Xia "Ben" Hu on interpretable machine learning. Though machine learning models have achieved a lot of success in different applications, they are often regarded as black-boxes and criticized by the lack of interpretability. To bridge the gap, we propose to develop interpretable systems to enhance the transparency of machine learning models. We will discuss the system architecture and main algorithms, as well as our current progress, to develop post-hoc interpretation approaches for convolutional neural network predictions of images, recurrent neural network predictions of text, and recommender system decisions.

5 - Coefficient Tree Regression for Discovering Structure in Generalized Linear Models

Ozge Surer, Northwestern University, Evanston, IL, 60201, United States, ozgesurer2019@u.northwestern.edu, Daniel Apley, Edward C. Malthouse

Massive regression data sets are now commonplace, with so many predictors that they cannot or should not all be included individually. In practice, derived predictors that are the sum of groups of individual predictors (which is equivalent to predictors within groups sharing the same coefficient) are often relevant. However, the groups of predictors are often not known in advance, and they must be discovered from the data. In this study, we extend our coefficient tree regression algorithm to generalized linear models to discover the group structure from the data.

■ TE02

CC- Room 202

Learning and Optimization in Social Media

Sponsored: Data Mining

Sponsored Session

Chair: Zhecheng Qiang

1 - Link Predictions for Social Networks in Online Health Communities

Sulyun Lee, The University of Iowa, Iowa City, IA, United States, sulyun-lee@uiowa.edu

Online Health Communities (OHCs) are popular sources for patients and their families to get informational and emotional support related to the diseases or symptoms. As users interact with each other, they also form a social network. We try to predict the links that are likely to be formed in such a network to improve patients' experience in an OHC. Our model considers the different types of relationships among users, users' levels of online activities, as well as the topics of their online discussions. We show that our model outperforms benchmark methods in predicting future social network links.

2 - Sequential Stochastic Assignment with Unknown Worker Quality

Siddhartha Nambiar, North Carolina State University, Raleigh, NC, 27603, United States, snambia@ncsu.edu, Alexander Nikolaev, Alexander Semenov

We consider a worker assignment problem where the quality of the workers is not fully known prior to making assignments. We frame this problem as a variant of the Sequential Stochastic Assignment Problem (SSAP), workers with given success rates are assigned non-anticipatively to sequentially-arriving tasks in order to maximize the total expected reward; every task value follows a given distribution and remains unknown until the task presents itself to the workers. In our case, we tackle the lack of the worker success rate information by using a number of techniques for inferring a consensus ranking of objects from a limited number of available pairwise comparisons between these objects.

3 - Reinforcement Learning in Information Cascade Based on Dynamic User Behavior

Mengnan Chen, University of Central Florida, Orlando, FL, United States

Cascading phenomena are typically characterized by a dynamic process of information propagation between nodes in a network, where nodes can rebroadcast or repost information from and to their neighbors. Our model is based on the Markov Decision Process (MDP) with uncertain nodes/users behavior and dynamic network topology, which aims to find the optimal policy for agents to select the information source seed to maximizing the influence in the information cascade within finite-time horizon. To model their autonomous behaviors, we will implement the concepts of discrete choice models from behavioral economics.

4 - Model-based Learning of Information Diffusion Dynamics in Social Media Networks

Zhecheng (Jennifer) Qiang, University of Central Florida, Orlando, FL, 32826, United States, Eduardo Pasiliao, Qipeng Phil Zheng

Learning the information diffusion process is essential for successful applications of viral marketing and cyber security in social media networks. We propose two learning models that aim at learning person-to-person influence in information diffusion from historical cascades based on the threshold propagation model. The first model is based on the Linear Threshold Propagation Model. In addition, by considering multi-step information propagation, we build a learning model for multi-step diffusion influence based on the idea of random walk. For large-scale networks, we develop approximate methods of learning models using artificial neural networks to learn the pairwise influence.

■ TE03

CC- Room 203

Data Driven Policy Evaluation

Sponsored: Data Mining

Sponsored Session

Chair: Md Noor E Alam

1 - Evaluating Hospital Readmission Reduction Program with Robust Causal Inference Test

Noor E. Alam, Northeastern University, Boston, MA, MA 02115, United States, Md Saiful Islam, Md Sarowar Morshed, Gary Young

Evaluating policy is essentially a causal inference problem. Matching methods, especially propensity score matching, has been widely used for policy evaluation from observational data. However, in one-to-one matching, multiple matching methods can produce different results which make the evaluation process dependent on the choice of the experimenter. In this study, we develop algorithms which ensure robustness in making causal inference and are scalable to large-scale observational studies. We test the algorithms by evaluating the Hospital Readmission Reduction Program (HRRP) policy.

2 - Causal Impact Analysis of the Impact of Homecare Services on Patient Discharge Disposition

Sabrina Casucci, Assistant Professor of Teaching, Buffalo, NY, 14227, United States, scasucci@buffalo.edu, Yuan Zhou, Biplab Sudhin Bhattacharya, Lei Sun, Alexander Nikolaev, Li Lin

This study uses observational causal inference to evaluate the impact of different combinations of home care services (nursing, therapies, social work, home aides) on end-of-episode disposition for individuals with chronic diseases associated with the circulatory, endocrine, and musculoskeletal systems. The potential to generate actionable recommendations in policy for personalizing home care services, or treatment plans, from limited clinical and care needs data is demonstrated through the results.

3 - Smooth Contextual Bandits: Bridging the Parametric and Non-differentiable Regret Regimes

Yichun Hu, Cornell University, New York, NY, United States, yh767@cornell.edu, Nathan Kallus, Xiaojie Mao

We study a non-parametric contextual bandit problem where the arms are Holder functions with smoothness parameter . We show how this interpolates between two extremes that were previously studied in separation: non-differentiable bandits (≤1) and parametric bandits (->∞). We develop a novel algorithm that carefully adjusts to all smoothness settings and achieves rate-optimal regret in either extreme, recovering existing results. In this sense, our result bridges the gap between the existing literatures on parametric and non-parametric contextual bandit problems and between bandit algorithms that use global and local reward information.

4 - Hospital Readmissions to Non-index Hospitals: Patterns and Determinants Following the Medicare Readmission Reduction Penalty Program

Noor E. Alam, Northeastern University, Boston, MA, MA 02115, United States, Mahmudul Hasan, Xiaoyi Wang, E. David Zepeda, Gary J. Young

Leveraging the state of California hospital discharge data, this study investigates the patterns and determinants of non-index readmissions for Medicare and non-Medicare patients to identify whether or not such general pattern of non-index readmission have significantly changed following the adoption of Hospital Readmission Reduction Program (HRRP).

■ TE04

CC- Room 204

Recent Advances in Data Mining

Sponsored: Data Mining

Sponsored Session

Chair: Daoji Li

1 - Sparsity Double Robust Inference of Average Treatment Effects

Yinchu Zhu, PhD, University of Oregon, Eugene, OR, 97403, United States, yzhu6@uoregon.edu, Jelena Bradic, Stefan Wager

Popular methods for building confidence intervals on causal effects under high-dimensional confounding require strong "ultra-sparsity" assumptions that may be difficult to validate in practice. To alleviate this difficulty, we study a new method for average treatment effect estimation that yields asymptotically exact confidence intervals assuming that either the conditional response or the propensity score allows for an ultra-sparse representation (but not necessarily both). This guarantee allows us to provide valid inference for average treatment effect in high dimensions under considerably more generality. We also show that our results are semi-parametrically efficient.

2 - Simultaneous Estimation for Semi-parametric Multi-index Models

Wenbo Wu, PhD, University of Texas at San Antonio, San Antonio, TX, 78249, United States

Estimation of a general multi-index model comprises determining the number of linear combinations of predictors (structural dimension) that are related to the response, estimating the loadings of each index vector, selecting the active predictors, and estimating the underlying link function. These objectives are often achieved sequentially at different stages of the estimation process. In this study, we propose a unified estimation approach under a semi-parametric model framework to attain these estimation goals simultaneously. The proposed estimation method is more efficient and stable than many existing methods.

3 - High-Dimensional Interaction Detection with False Sign Rate Control

Daoji Li, Assistant Professor, California State University-Fullerton, Fullerton, CA, 92831, United States

Understanding how features interact with each other is of paramount importance in many scientific discoveries and contemporary applications, such as Marketing, Economics, social science, medicine, and environmental science. Yet interaction identification becomes challenging even for a moderate number of covariates. In this talk, I will introduce an efficient and flexible procedure for interaction identification in ultra-high dimensions. Our method enjoys oracle inequalities in interactions and main effects selection and admits an explicit bound on the false sign rate, which can be asymptotically vanishing. Our method and theoretical results are supported by several numerical studies.

4 - Efficient Estimation of Multivariate Models for Longitudinal Data under Local Box-Cox Transformation

Mohammed Chowdhury, PhD, Kennesaw State University, Kennesaw, GA, 30144, United States, mchowd10@kennesaw.edu

An efficient method to estimate functional linear models and bivariate probability models has been proposed and developed for the longitudinal data under the framework of Local Box-Cox transformation (LBCT). First, we split the data. We then apply LBCT on each data in second step, and in third step, we accomplish efficient estimation of our models by incorporating three nonparametric smoothers on entire time range. Relevant asymptotic properties of the smoothing estimators are derived. Application of our method is demonstrated through a longitudinal study of childhood growth and blood pressure. Finite sample properties our procedures are investigated by simulation study.

■ TE05

CC- Room 205

Statistical Machine Learning and Data Analytics with Applications in Complex Systems

Sponsored: Data Mining

Sponsored Session

Chair: Bing Si

1 - Constrained Markov Decision Process Modeling for Sequential Optimization of Additive Manufacturing Build Quality

Bing Yao, PSU, State College, PA, 16801, United States, Hui Yang

Additive manufacturing enables the creation of complex and freeform geometries, but lacks the ability to perform real-time quality control. This paper presents a new sequential decision-making framework for in-situ control of AM build quality, which optimizes corrective actions to be taken for repairing incipient defects prior to completion.

2 - Collusion Detection and Ground Truth Inference in Crowdsourcing for Labeling Tasks

Changyue Song, University of Wisconsin-Madison, Mechanical Engineering Building, 1513 University Ave, Madison, WI, 53715, United States, csong39@wisc.edu, Kaibo Liu, Xi Zhang

Crowdsourcing has been a prompt and cost-effective way of obtaining labels in many machine learning applications. In the literature, a number of algorithms have been developed to infer the ground truth based on the collected labels. However, most existing studies assume workers to be independent and are vulnerable to worker collusion. This paper aims at detecting the collusive behaviors of workers in labeling tasks. Specifically, we propose a penalized pairwise profile likelihood method based on the adaptive LASSO penalty and investigate the theoretical properties. Numerical studies using synthetic and real data sets are conducted to test the performance of the method.

3 - Motion Artifact Removal Using Joint Basis Pursuit Linear Program for Accurate Heart Monitoring

Amirhossein Koneshloo, TexasTech University, Lubbock, TX, 79415, United States, Dongping Du

This study develops a novel method to effectively attenuate the impact of motion artifact (MA) on Photoplethysmography (PPG) signals and accurately identify Heart Rate (HR) variations during physical exercise. Joint basis pursuit linear program is used to decompose PPG signal into different time series. The time series that are highly correlated with acceleration signals are removed to eliminate MA. A new sparse spectra reconstruction method is designed to rebuild the spectrum of HR in current time window based on the previous time frame. The algorithm shows good robustness as it requires a small set of parameters and can provide accurate estimations when PPG signals are contaminated by strong MA.

4 - Multi-printer Co-learning of Kinematics-induced Variations for Inter-connected Extrusion-based Additive Manufacturing

Hui Wang, Assistant Professor, FAMU-FSU College of Engineering, Tallahassee, FL, 32303, United States, huiwz.wang@gmail.com, Jie Ren, An-Tsun Wei

For extrusion-based additive manufacturing, the inconsistent amount of deposited material along the printing path greatly affects the product quality and are usually affected by kinematic variations of the printer extruders. This talk presents a mathematical model that quantifies the printing line variations induced by extruder kinematics characteristics. It provides a way of between-printer knowledge sharing and transfers on estimating the extrusion variations. Based on the model, a co-learning method is developed to improve the quality prediction model for a 3D printer with limited historical data by leveraging the data from similar 3D printers.

■ TE06

CC- Room 209

Predictive Modeling in Medical Decision Making

Sponsored: Data Mining

Sponsored Session

Chair: Mohammad Samie Tootooni, Mayo Clinic, Rochester, MN, 55906, United States

1 - A Causal Analysis of Patient Portal and its Impact on Primary Care Service Utilization and Appointment Adherence

Xiang Zhong, University of Florida, Gainesville, FL, United States, Jaeyoung Park, Muxuan Liang

The objective of this study was to investigate the characteristics of primary care patients using different patient portal functions and the impact of portal usage on patients' primary care service utilization and appointment adherence. A retrospective observational study using a large dataset from the University of Florida (UF) Health was conducted. Patients were classified into different user subgroups based on their portal usage of messaging, laboratory, appointment, and medication functions. Generalized linear models were built and a difference-in-differences analysis was conducted to compare the time-dependent portal usage effects across different user subgroups and nonusers.

2 - Learning Severity of Illness Scores from EHR Data: A Mixed-integer Programming Approach

Joseph Kapena Agor, Oregon State University, Corvallis, OR, 27606, United States, agorj@oregonstate.edu, Osman Ozaltin

The current state of the art in the development of scoring systems in health care is to take weights that are generated by statistical learning models and round them to obtain integer point values for the scores. This could potentially eliminate important variables, reduce calibration of the score and also leads to sub-optimality. Therefore, we propose a mixed integer programming framework for the development of severity of illness scores. We apply the framework to construct a score that can be used to track the acuity of patients who are susceptible to sepsis. We find that our model produces an interpretable and accurate score compared to others in the current literature.

3 - Optimizing Screening Policies for Hospital-acquired Infections using MDP: The Case of MRSA Surveillance among Exposed Roommates in Canadian Hospitals

Esma Akgun, University of Waterloo, 350 Columbia Street West, Waterloo, ON, N2L 6P8, Canada, F. Safa Erenay, Sibel Alumur Alev

We develop a Markov Decision Process (MDP) model to predict the spread of hospital-acquired infections and apply it to optimize the screening policy for the exposed roommates of Methicillin-Resistant Staphylococcus Aureus (MRSA) carriers in a Canadian hospital. Unlike the existing analytic models, our model captures the spread of the infection within the room structure of a hospital. We consider several performance measures including quality-adjusted life years, cost of mitigating MRSA spread, number of colonized patients, and the number of missed MRSA cases.

4 - A Progressive Prediction Modelling Approach in Evaluating Vancomycin Dosing Strategy

Mohammad Samie Tootooni, Mayo Clinic, Rochester, MN, 55906, United States

Please check the mobile app for this abstract.

■ TE07

CC- Room 210

Transforming Markets through Data Mining: New Tools and Cutting-Edge Techniques

Sponsored: Data Mining

Sponsored Session

Chair: Pankhuri Malhotra

1 - The Power of Online Brand Ecosystems

Pankhuri Malhotra, University of illiinois-Chicago, Chicago, IL, 60613, United States, pmalho3@uic.edu, Siddhartha Bhattacharyya

Mining consumer-brand perceptions is a dominant area of research. We address this knowledge area by exploiting Twitter brand communities to generate a large-scale brand network, that implicitly captures consumer perceptions. We statistically examine the network using Exponential-Random-Graph-Models and confirm that associations between brands do not arise from randomness. Network measures are used to create perceptual maps along the dimensions: mainstream and diverseness. Our work conceptualizes brands as relationships rather than as isolated objects; thus, allowing managers to quantify the impact of their branding efforts on consumers' perceptions and performance simultaneously.

2 - Topic Modeling of Textual Data

Yuan Cheng, Cornell College of Business, Ithaca, NY, United States

Analyzing text for business applications requires interpretable summaries in addition to prediction accuracy. We propose a new constrained matrix factorization model, which balances maximizing statistical and predictive power of regression models with capturing the underlying textual themes. We validate the effectiveness of our proposed model in terms of the combined goal with a comprehensive benchmarking study with online reviews.

3 - Understanding Physicians' Online-offline Behavior Dynamics: An Empirical Study

Tongxin Zhou, University of Washington, Seattle, WA, 98105, United States, Liuan Wang, Lu Yan, Xitong Guo, Gregory R. Heim

Physicians' online participation serves to integrate online healthcare resources with offline medical systems. This integration brings opportunities for reshaping healthcare delivery systems. Although, there has been extensive discussion about physician participation, little is known about how physicians actually participate in both online and offline channels. In this study, we investigate physicians' online-offline behavior dynamics. By using a time-series technique: a structural vector autoregression (SVAR) model, we find that physicians' online activities can lead to a higher offline service quantity, whereas offline activities may reduce physicians' online contribution.

4 - The Impact of Emotion on Social Media Content Consumption: Evidence from Video Analysis on Live Streaming Platforms

Keran Zhao, University of Illinois at Chicago, Chicago, IL, 60613, United States, kzhao23@uic.edu, Yuheng Hu, Yingda Lu, Ning Shi

As an emerging social media service, live streaming has been widely adopted by advertisers and companies as a powerful market tool. In this study, we examine how streamers' emotional expression influence the audience's engagement. To answer this question, we utilize the deep-learning methods to acquire both the emotional expression and audience attention from streaming video and chatting script. Our analysis yields that there is a positive relationship between emotion fluctuation and audience engagement. Our results provide actionable suggestions and shed light on understanding the live interaction on the live streaming platforms.

5 - Inferring Brand Knowledge from Online Consumer Associative Brand Networks

Minghong Xu, Johns Hopkins Carey Business School, Baltimore, MD, 60201, United States

Consumer perceptions of a brand is key to brand value. Traditional methods rely on time-consuming and expensive approaches like surveys and focus groups to elicit such perceptions; these are also very limited in terms of reach across consumers and brands. This paper examines consumer associative brand networks inferred from large-scale data on consumers' engagement across a broad collection of brands. It presents a statistical analyses of brand networks, to help determine whether such networks obtained from large-scale data on consumer co-interest in social media provide a valid and reliable source of brand insights and knowledge.

■ TE08

CC- Room 211

AI Techniques for Decision Support

Sponsored: Artificial Intelligence

Sponsored Session

Chair: Zhengchao Yang, Arizona State University, Tempe, AZ, 85281, United States

Co-Chair: Xuan Wei, University of Arizona, Tucson, AZ, 85721, United States

1 - Automated Training Data Discovery and Labelling for Machine Learning in a Low Resource Domain

Yang Gu, The University of Arizona, Tucson, AZ, United States, Gondy Leroy

The CDC's surveillance program on Autism Spectrum Disorder (ASD) has found that ASD affects one in 59 children in the US. Its prevalence has more than doubled since 2000. To better study this condition, we leverage natural language processing techniques, including machine and deep learning, to automate the identification of ASD diagnostic criteria in electronic health records (EHRs). This presentation will discuss some work undertaken to supplement machine learning training data when working in a low-resource domain with small amounts of labelled data.

2 - Predicting User Activities in Online Health Communities via Trajectory Mining

Xiangyu Wang, University of Iowa, Iowa City, IA, United States, xiangyu-wang-1@uiowa.edu, Kang Zhao, Xun Zhou, Nick Street

Online Health Communities (OHCs) are a great source of social support for patients and their caregivers. Better predictions of user activities from OHCs can help to manage and sustain a successful OHC. This paper addresses the problem of predicting OHC user activities, especially for active users who suddenly disappear. Our approach uses LSTMs to learn from users' temporal activity trajectories and incorporates users' topics distributions over time. Experiments based on data from a popular OHC for cancer survivors show that the proposed model can improve the performance of user activity prediction.

3 - Health Suggestion Mining from Online Health Forums

Zhengchao Yang, University of Arizona, School of Computing, Informatics, and, Decision System Engr, Tucson, AZ, 85281, United States

Suggestion mining is to identify good suggestions for given questions. In the study, we focus on suggestions ranking problem for an online health forum where users can ask questions and suggestions are provided by qualified doctors or patients with similar conditions. We propose a novel word/sentence level attention CNN based on contextual word embeddings to automatically rank the suggestions for health questions based on the suggestion quality. Our framework requires minimal feature engineering and receives good performance in detecting quality suggestions for questions. The method is also able to extract key terms of questions that a quality suggestion is targeting in solving problems for.

4 - Data-Driven Optimization for Team Formation

Teng Huang, University of Connecticut, Storrs, CT, United States, teng.huang@uconn.edu, David Bergman, John Mathieu

We propose a predictive-and-prescriptive analytics framework for a team formation problem. First, we train predictive models to learn the relationships between the collection team member's characteristics and the outcome or success of the team they compose. The maximum scores in a team predict better than the average scores. The best model is a polynomial regression model. Next, we propose five algorithms for partition N people into t teams and maximize the average team performance. The BDD-based algorithm can solve instances in which it's hard to enumerate all possible team formation.

■ TE09

CC- Room 212

New Developments in AI Learning Models & Methods for Optimization

Sponsored: Artificial Intelligence

Sponsored Session

Chair: Yu Du, University of Colorado Denver, Denver, CO, 80202, United States

Co-Chair: Fred Glover

Co-Chair: Gary Kochenberger, University of Colorado-Denver, Denver, CO, 80202, United States

1 - QUBO Models in Optimization, Machine Learning, and Quantum Computing

Yu Du, University of Colorado Denver, Denver, CO, 80202, United States, duyu197@gmail.com, Fred Glover, Gary Kochenberger

The Quadratic Unconstrained Binary Optimization model, associated with the Ising problem in physics, has emerged as an underpinning of the quantum annealing area and neuromorphic computing. This talk discloses the basic features of the QUBO model. Computational experience is being amassed by both the classical and the quantum computing communities that highlights not only the potential of the QUBO model but also its effectiveness as an alternative to traditional modeling and solution methodologies. We also describe recent innovations for solving QUBO models that offer a fertile avenue for integrating classical and quantum computing and for applying these models in machine learning.

2 - What to Learn and What Not to Learn: A Mathematical View on Ethical Learning

Endre Boros, Distinguished Professor, Rutgers University, Piscataway, NJ, 08854-8003, United States, Endre.Boros@rutgers.edu

Learning algorithms are struggling with large data sets, and miss information present in the data simply for computational reasons. A larger and mostly hidden problem is that many algorithms learn (unintentionally and unnoticed) patterns that are not supported by data. Both errors imply potential problems: missing important triggers and/or using unsupported ones. This brings up both ethical and legal questions. In this talk we demonstrate these issues with an example. We propose a mathematically sound notion of a “justifiable” classifier AND learning algorithm. On the positive side, we show some results about the existence of learning algorithms that always produce a “justifiable” classifier.

3 - Model Based Tabu Search Algorithms for the Independent Quadratic Assignment Problem

Wei Yang, Northwestern Polytechnical University, Xi’an, V3S 8M9, China, Yang Wang, Abraham P. Punnen, Ante usti

We study the independent quadratic assignment problem (IndQAP) which is a special case of the bilinear assignment problem. A characterization of linearizable cost matrices for the IndQAP is presented. Further, we propose several model based tabu search algorithms that explore the underlying large scale neighborhoods by solving corresponding linear assignment problems with appropriate guiding mechanism. Extensive experimental results are presented. We also introduce a set of benchmark test instances that can be used for future experimental study on IndQAP.

■ TE10

CC- Room 213

Mining Online Health Communities

Sponsored: Social Media Analytics

Sponsored Session

Chair: Qingpeng Zhang, City University of Hong Kong, Kowloon, 12180, Hong Kong

1 - Recent Results in Simulating Social Networks

Jiang Wu, Wuhan University, School of Information Management, Wuchang, Wuhan, 430072, China

This presentation describes recent results in simulating social network evolution.

2 - Cross Cultural Comparisons of User Participation and Social Support Exchange in Online Health Communities

Xi Wang, Central University of Finance and Economics, School of Information, Beijing, 100080, China, xiwang@cufe.edu.cn

Online Health Communities (OHCs) are used worldwide, but it remains unclear how people from various culturalbackgrounds utilize this channel. By analyzing two representative breast-cancer-related OHCs from China and the US respectively, this study is the first attempt to investigate cultural differences in terms of social support exchange through user-generated content by data mining methods. The findings have both theoretical and practical implications for researchers and OHC stakeholders.

3 - Factors Influencing Online Giving Performance: An Integration of the Elaboration Likelihood Model and Social Influence Theory

Danyang Song, Zhejiang University, Hangzhou, China, dysong@zju.edu.cn, Yin Pan, Xi Chen

By integrating the two traditionally separate areas of elaboration likelihood model (ELM) and social influence theory, our research aims to build a more complete theoretical model for online giving. The results manifest that both ELM and social influence have significant effects on fundraising performance of charitable giving projects. Contrary to our expectation, the central route of ELM is negatively related with fundraising performance. In addition, both informational and normative social influences as well as the urgency of demand play a strengthening role in moderating the relationship between the peripheral route of persuasion and fundraising performance, but not the central route.

4 - Knowledge Enhanced Best Answer Selection in Community Question Answering Systems

Qingpeng Zhang, City University of Hong Kong, Kowloon, 12180, Hong Kong, qingpeng.zhang@cityu.edu.hk, Fengshi Jing

In this research, we present a novel attentive-pooling deep learning approach to selecting the best answers in online community question answering (CQA) systems. The model is enhanced with knowledge extracted from the community including prior questions, answers, and social networking behaviors. Experiments with both general and vertical CQA systems demonstrate the superior performance of the proposed approach.

■ TE11

CC- Room 214

Applied Probability: Queues and Epidemics

Sponsored: Applied Probability

Sponsored Session

Chair: Jamol Pender, Cornell University, Ithaca, NY, 14850, United States

1 - The Queue- Hawkes Process: Ephemeral Self-excitement

Andrew Monroe Daw, Cornell University, Ithaca, NY, 14853, United States, amd399@cornell.edu, Jamol Pender

In this talk, we define a novel generalization of the self-exciting Hawkes process called the Queue-Hawkes process. This new stochastic process combines the dynamics of a self-exciting process and an infinite server queueing model: arrivals increase the arrival rate, but departures decrease it. Our study of this model includes connections to well-known stochastic models such as branching processes, random walks, epidemics, and Bayesian mixture models. Our results for the Queue-Hawkes process include a batch scaling construction of general Hawkes processes from a special affine case of the Queue-Hawkes process.

2 - Delay Announcements with Weighted Moving Averages

Jamol Pender, Cornell University, Ithaca, NY, 14850, United States, jjp274@cornell.edu

Many service systems use technology to notify customers about their expected waiting times or queue lengths via delay announcements. However, in many cases, either the information might be delayed or customers might require time to travel to the queue of their choice, thus causing a lag in information. In this work, we show that if the variance of the travel time is higher for a specific distribution, then oscillations are less likely to occur.

3 - Epidemic Spreading on Networks with Communities

Emily M. Fischer, PhD, Cornell University, Ithaca, NY, 14850, United States, ef363@cornell.edu

Online social networks and other networks of interest are known to exhibit community structure, where a community is a highly interconnected group of nodes. It is important to understand the role of community structure in the spread of information and infectious diseases. We show that under the Susceptible-Infected-Susceptible (SIS) epidemic model, the lifetime of an infection is constrained by the structure of individual communities and is highly dependent on the location of the initial infection. Without relying on any particular definition of community or method of community detection, we give a result bounding the epidemic threshold closely around the threshold of the strongest community.

4 - The Value of Flexible Customers via Join the Shortest of "d" Queues

Shuang Tao, Cornell University, Ithaca, NY, 14853, United States, st754@cornell.edu

We propose a multi-server queueing model that captures a performance trade-off between customers valuing flexibility or wanting dedicated service, which is motivated by healthcare platforms like Zocdoc where patients may choose to see a dedicated physician or choose among readily available physicians. In our model, a fraction of the customers are flexible and willing to join the shortest of d queues, while the remaining fraction only join the queue of their choice. We prove both a fluid and diffusion limit for the queueing model for the transient and steady-state dynamics. Our analysis illustrates not only the power of a bit of flexibility, but that flexibility benefits all and not just the flexible.

■ TE12

CC- Room 2A

Topics in Simulation Optimization

Sponsored: Applied Probability

Sponsored Session

Chair: Susan R. Hunter, Purdue University, West Lafayette, IN, 47907-2023, United States

1 - Simulation Optimization Using Biased Gradient Estimates

Shane Henderson, Cornell University, Cornell University, Ithaca, NY, 14853, United States, David J. Eckman

Solving simulation-optimization problems with continuous decision variables is eased with gradient estimates. Unfortunately, gradient estimates are often, or even usually, biased. For example, when using infinitesimal perturbation analysis such bias arises when there are discontinuities in the simulation output as a function of the decision variables, roughly speaking. In contrast to standard practice, we propose using the estimated gradients in a local search technique, even though they are biased. The resulting algorithm cannot converge to even a local minimum, but can yield practically significant improvements in a number of examples.

2 - Solving Bayesian Risk Optimization via Nested Stochastic Derivative Estimation

Sait Cakmak, Georgia Institute of Technology, School of Industrial and Systems Engineering, Atlanta, GA, 30332, United States, scakmak3@gatech.edu, Di Wu, Enlu Zhou

Stochastic simulation is driven by input parameters that are often estimated from finite data, leading to input uncertainty. To account for input uncertainty in simulation optimization, the Bayesian Risk Optimization (BRO) framework has been proposed, which aims to optimize the objective while hedging against input uncertainty. In order to efficiently solve the BRO problem, we derive stochastic derivative estimators and propose corresponding stochastic-approximation algorithms. Our estimators extend the literature of stochastic derivative estimation to the case of nested risk functions.

3 - Derivative Free Multiobjective Optimization with Surrogate Models

Juliane Mueller, Lawrence Berkeley National Lab, Berkeley, CA, 94702, United States, juliane.mueller2901@gmail.com

We present our algorithm development for derivative-free multiobjective optimization of computationally expensive simulation functions. We use surrogate models to approximate the expensive simulation objective functions. A variety of sampling methods allow us to explore the extrema of the approximated Pareto front, to fill gaps in the approximated Pareto front, and to search locally for improvements of current Pareto optimal solutions. We show that our algorithm performs better than widely used multiobjective genetic algorithms for a large number of fast-to-compute test problems and two applications from optimal design.

4 - Algorithms for Multi-objective Simulation Optimization on Integer Lattices with Three or More Objectives

Eric A. Applegate, Purdue University, School of Industrial Engineering, West Lafayette, IN, 47907-2023, United States, applegae@purdue.edu, Susan R. Hunter

We consider the multi-objective simulation optimization problem on integer lattices with three or more objectives. In this nonlinear optimization problem, the objectives can only be observed with stochastic error, and the decision variables are integer-valued. Among other recent advances, we discuss the Retrospective Multi-Gradient Search with Piecewise Linear Interpolation and Neighborhood Enumeration (R-MGSPLINE) algorithm for finding a local efficient point.

■ TE13

CC- Room 2B

Applied Probability in Finance

Sponsored: Applied Probability

Sponsored Session

Chair: Xuefeng Gao, Chinese University of Hong Kong, Shatin, Hong Kong

1 - Markov Chain Approximation of Sticky Diffusions with Financial Applications

Christian Meier, Chinese University of Hong Kong, Shatin, N. T, Hong Kong, Lingfei Li, Gongqiu Zhang

We consider general one-dimensional sticky diffusions defined as weak solutions of SDEs and show that there exists a unique weak solution under rather mild conditions. We develop continuous time Markov chain (CTMC) approximation for sticky diffusions and prove that it achieves second order convergence. We also propose a simulation scheme for stick diffusions based on CTMC approximation and show that it attains a weak convergence order of two. In contrast, traditional time discretization methods such as the Euler scheme completely fails. Computations for stick diffusion models for yield curves in low interest rate environment are given to illustrate the accuracy of our method.

2 - Dynamic Mean-variance Efficient Fractional Kelly Portfolios in a Stochastic Volatility Model

Xuedong He, The Chinese University of Hong Kong, Shatin, Hong Kong, xdhe@se.cuhk.edu.hk, Zhaoli Jiang

We improve the dynamic mean-variance efficiency of fractional Kelly strategies in a continuous-time stochastic volatility model by studying a mean-variance portfolio selection problem in which an agent achieves an expected return of her investment as high as that of a fractional Kelly strategy and minimizes the variance of her investment return. We solve in closed form the equilibrium strategy for the agent and find that the return rate of this strategy has smaller variance than that of the fractional Kelly strategy at any time. Finally, we derive an implied risk aversion degree of the agent and find that it is decreasing with respect to the market condition and to the investment horizon.

3 - Tail Risk Monotonicity under Temporal Aggregation in the GARCH(1,1) Model

Dan Pirjol, Stevens Institute of Technology, Hoboken, NJ, 07306, United States, dpirjol@gmail.com, Paul Glasserman, Qi Wu

The talk considers the properties of the tail asymptotics of the unconditional distribution of returns in the GARCH(1,1) model under temporal aggregation. The unconditional distribution of the n-step returns rn has power-law tails P(rn> x) x-k(n) with a calculable exponent (n). We derive a criterion for strict (increasing) monotonicity of the map n > (n), and show that it is satisfied in a large region of the GARCH(1,1) parameter space, for a wide choice of innovations. Exceptions to the monotonicity criterion appear in a small corner of the GARCH(1,1) parameter space whch is mapped explicitly for the most popular innovations (normal, doubly-exponential and Student-t).

4 - Affine Point Processes: Refinements to Large-time Asymptotics

Xuefeng Gao, Chinese University of Hong Kong, Shatin, Hong Kong, xfgao@se.cuhk.edu.hk

Affine point processes are a class of simple point processes with self- and mutually- exciting properties, and they have found applications in many areas. In this paper, we obtain large-time asymptotic expansions in large deviations and refined central limit theorem for affine point processes, using the framework of mod- convergence. Our results extend the large-time limit theorems in [Zhang et al. 2015. Math. Oper. Res. 40(4), 797-819]. The resulting explicit approximations for large deviation probabilities and tail expectations can be used as an alternative to importance sampling Monte Carlo simulations. Numerical experiments illustrate our results. This is a joint work with Lingjiong Zhu.

■ TE14

CC- Room 302

Issues in Supply Chain Management in the Pharmaceutical Industry

Sponsored: Manufacturing & Service Oper Mgmt

Sponsored Session

Chair: Eda Kemahlioglu-Ziya

1 - A Portfolio Optimization Approach to Pharmaceutical Capacity Allocations

Iva Rashkova, Washington University in St Louis, St Louis, MO, United States, irashkova@wustl.edu, Panos Kouvelis

Insufficient manufacturing capacity is a reason for nationwide drug shortages. We use a portfolio optimization approach to study the drug capacity allocation problem. A manufacturer's drug portfolio changes over time as new drugs are approved and existing drugs are discontinued. A mathematical model illustrates the relationships between pipeline and existing drugs in a portfolio. We examine empirically these relationships using time series data of drug shortages, clinical trials, approvals and discontinuations. Furthermore, we build predictive models of aggregate drug shortages and test them on out-of-sample data.

2 - Studying Trust Dynamics in a Disrupted Supply Chain

Rozhin Doroudi, Northeastern University, Boston, MA, United States, doroudi.r@husky.neu.edu, Ozlem Ergun, Jacqueline Griffin

Prolonged drug shortages in United States threatens public health and patients' safety. Despite drastic effects of these shortages, more than half of the time the reason for them are unknown. However anecdotal evidence suggests that part of these shortages is resulted from human behavior. Driven by the public safety risk in this setting, we model a pharmaceutical supply chain with boundedly rational decision makers which are capable of reasoning about reaction of other decision makers. Having these realistic models of human behavior enables us to study effects of trust dynamics in a disrupted supply chain.

3 - Drug Shortages and Paths to Capacity Creation

Eda Kemahlioglu Ziya, North Carolina State, Poole College of Management, Raleigh, NC, 27695-7229, United States, ekemahl@ncsu.edu, H. Sebastian Heese

Drug shortages are becoming more prevalent in the U.S. We study why manufacturers refrain from adding/maintaining capacity and why so few manufacturers enter the generic drugs market where most drug shortages arise. To moderate drug shortages, the government can either directly affect the reimbursement policies for pharmaceutical companies and/or the cost of entering and remaining in the market. In this paper, our goal is to study the effectiveness of these two levers in increasing the industry supply for one drug.

4 - Does Medicare's Drug Reimbursement Policy Reform Aggravate Drug Shortages? Theoretical and Scenario Analyses

Hui Zhao, The Pennsylvania State University, Smeal College of Business, University Park, PA, 16802, United States, huz10@psu.edu, Xuejun Zhao, Justin Jia

In 2005, Medicare reforms its drug reimbursement policy from an Average Wholesale Price regime to an Average Sales Price regime. The years following the reform witnessed severe drug shortages. We use analytical model and data analysis to address the continued arguments on whether the policy reform aggravated the drug shortages.

■ TE15

CC- Room 303

Business Management in Big Data Era

Sponsored: Manufacturing & Service Oper Mgmt

Sponsored Session

Chair: Jian Chen, Tsinghua University, Beijing, 100084, China

Co-Chair: Yong Tan, University of Washington, Seattle, WA, 98195-3226, United States

Moderator

Jian Chen, Tsinghua University, Dept of Mgmt Science, School of Economics & Mgmt, Beijing, 100084, China

Panelists

- Lihua Huang, Fudan University, China
- Subodha Kumar, Temple University, Philadelphia, PA, United States
- Jian Chen, Tsinghua University, Dept. of Mgmt Science, School of Economics & Mgmt, Beijing, 100084, China
- Yong Tan, University of Washington, Michael G. Foster School of Business, Seattle, WA, 98195-3226, United States
- Qiang Ye, Harbin Institute of Technology, School of Management, Harbin, China

■ TE16

CC- Room 304

Strategic Behavior in Service Systems

Sponsored: Manufacturing & Service Oper. Mgmt/Service Operations

Sponsored Session

Chair: Pnina Feldman, Boston University, Boston, MA, 02215, United States

Co-Chair: Ricky Roet-Green, University of Rochester, Rochester, NY, 14627, United States

1 - A Model of Queue-Scalping

Luyi Yang, Johns Hopkins University, Baltimore, MD, 21202, United States, luyi.yang@jhu.edu, Shiliang Cui

Recent years have witnessed the rise of queue-scalping in congestion-prone service systems. A queue-scalper has no material interest in the primary service but proactively enters the queue in hopes of selling his spot later. This paper develops a queueing-game-theoretic model of queue-scalping and examines its implications for the service system. Contrary to conventional wisdom, we find that queues with an intermediate demand volume are most susceptible to scalping, rather than queues with either very small or very large demand volume. This result implies that an effort to mitigate scalping through capacity expansion may only lead to the presence of more scalpers.

2 - The Paradox of Choice: The False Premise of Omnichannel Services and How to Realize it

Yang Li, The Chinese University of Hong Kong, Hong Kong, Opher Baron, Xiaole Chen

Omni-channel service, an integration of in-store service with online ordering, has been thriving. This work studies the impacts of the omni-channel capability in the service industry. We adopt a game-theoretical queueing framework to explore customer channel choices and investigate the efficiency of the omni-channel system in comparison with a conventional walk-in only system. Our results unveil the inefficiency of the omni-channel system due to self-interested channel choices. We, thus, suggest several operational strategies that may curtail this inefficiency for a win-win outcome: the provider is able to improve her revenue while customers also enjoy higher social welfare.

3 - Impatience and Learning in Queues

Senthil Veeraraghavan, University of Pennsylvania, Wharton School OPIM Department, 545 3730 Walnut Street, Philadelphia, PA, 19104, United States, senthilv@wharton.upenn.edu, Li Xiao, Hanqin Zhang

Customers often abandon waiting in queues when they get impatient. Prior literature on Markovian queues shows that it is not rational for customers to quit "midway": Customers should either quit immediately on arrival (balk) or wait till the completion of their service. We show how in-queue abandonment behavior can be rational in queues because of learning. We compare how rational Bayesian customers make abandonment decisions under different information disclosures. Our paper reveals interesting features in waiting behavior, showing that customers can be (rationally) more patient in slower, shorter queues, than in faster, longer queues.

4 - Paying by the Hour: Are Wages the Cost of Waiting?

Simin Li, Kellogg School of Management, Northwestern University, 2211 Campus Drive, Evanston, IL, 60208, United States, simin.li@kellogg.northwestern.edu, Achal Bassamboo, Martin Lariviere

We investigate how an agent's cost of waiting depends on compensation structures and non-market activities. We find the conventional metric, marginal wage, is only a fair estimation to marginal cost of waiting if earnings are smooth. The equality breaks down once any friction is introduced. The marginal wage can over or under estimate agent's true cost of waiting. In fact, with frictions in the compensation structures, the hourly wage by itself tells almost nothing about agent's cost of waiting.

■ TE17

CC- Room 305

Stochast Models in Service Operations

Sponsored: Manufacturing & Service Oper. Mgmt/Service Operations

Sponsored Session

Chair: Baris Ata, University of Chicago, Chicago, IL, 60637, United States

Co-Chair: Xiaoshan Peng, Indiana University, Bloomington, IN, United States

1 - Self-exciting Poisson Auto-regressive Models for Arrival Data

Zeyu Zheng, Assistant Professor, University of California, Berkeley, Berkeley, CA, United States, zyzheng@berkeley.edu, Peter W. Glynn

Self-exciting features are commonly seen in arrival data to various stochastic systems. Appropriately modeling and statistically characterize such features are important for decisions and performance prediction in such systems. In this talk, we discuss a toolbox that involves statistical estimation, inference, applied probability properties, and model selection for general Poisson auto-regressive models.

2 - A New Approach to High Dimensional Dynamic Pricing

Yilun Chen, Cornell, Ithaca, NY, 14853, United States, yc2436@cornell.edu, David Goldberg

Recently there has been considerable interest in studying dynamic pricing problems with more realistic/complex demand and supply structures. These problems are often formulated as high-dimensional stochastic dynamic programs which suffer from the curse of dimensionality. We propose an algorithm that overcomes this computational challenge for a fairly general class of pricing problems, subject to the retailer only being able to change the price of goods a small number of times. Our results leverage a recent algorithm for optimal stopping, hold for arbitrarily complex demand/supply structure, and have runtime effectively independent of the dimension.

3 - Revenue Maximization in Two-Station Tandem Queueing Systems

Xinchang Wang, Washington State University, Marketing Department, Pullman, WA, 39762, United States, Sigrun Andradottir, Hayriye Ayhan, Tonghoon Suk

We study optimal pricing for tandem queueing systems with finite buffers. The service provider dynamically quotes prices to customers to maximize the long-run average revenue. We build a Markov decision process model for the problem. For systems with general buffers, we describe the structure of the optimal dynamic pricing policy and develop tailored policy iteration to find an optimal pricing policy. For systems with no intermediate buffers, we characterize conditions under which quoting either a high or a low price to all customers is optimal and provide an algorithm to solve the problem. Numerical experiments are provided to compare the algorithms with the regular policy iteration algorithm.

4 - Optimal Admission Control Policies for Non-stationary Arrivals: A Dual Approach

Xiaoshan Peng, Indiana University, Kelley School, Bloomington, IN, United States, xp1@iu.edu

We consider the classical admission control problem for a single-server queue. The system incurs a waiting cost of h per unit time for each customer waiting in the queue, whereas it incurs a one-time penalty of p if the customer is rejected. We allow the arrival process to be a general stochastic process. We formulate the problem as a finite-horizon stochastic control problem and derive its dual. The solution to the dual problem can be interpreted as the expected cost incurred by the incoming customer at the moment. The solution to the dual problem can be interpreted as the shadow price process. We show that this process can be characterized using the conditional expectation time to empty the system.

■ TE18

CC- Room 306

Smart City Logistics and Supply Chain Management

Sponsored: Manufacturing & Service Oper. Mgmt/Supply Chain

Sponsored Session

Chair: Max Shen, JD.com, Santa Clara, CA, 95054, United States

Co-Chair: Junyu Cao, Albany, CA, 94706, United States

1 - Last-mile Shared Delivery: A Discrete Sequential Packing Approach

Junyu Cao, University of California Berkeley, Berkeley, CA, 94706, United States, jycao@berkeley.edu, Mariana Olvera-Craviotoo, Zuo-Jun Max Shen

We propose a model for optimizing the last-mile delivery of n packages from a distribution center to their final recipients, using a strategy that combines the use of ride-sharing platforms (e.g. Uber or Lyft) with a traditional van infrastructure. Our technical approach is based on the formulation of a discrete sequential packing problem, which is closely related to Renyi's parking problem. The main objective is to compute the optimal reward offered to private drivers for each individual package in a way that minimizes the total expected cost for delivering all packages. We show that under natural assumptions our mixed strategy can achieve significant improvements compared to a van-only strategy.

2 - The Impact of Last Mile in Service Industry

Meng Li, Rutgers University, Camden, NJ, 08102, United States, Ruomeng Cui, Jingbo Zhou

This paper investigates the price and quality response strategies of restaurants to people's easier last-mile travel. Our identification strategy exploits a quasi-randomized entry of the bike-sharing service—-a recent disruptive innovation which enables people to travel conveniently to places like restaurants—-to different cities. We construct a unique dataset of 980,511 restaurants' pricing and service rating before and after the entry of bike-sharing in China. We find that the entry of bike-sharing (1) reduces restaurants' pricing by 2%, (2) increases service quality by 2%, and (3) does not cause more entries or exits.

3 - Distributionally Robust Quantile Prediction Conditioning on Covariates

Meng Qi, University of California, Berkeley, Berkeley, CA, 94704, United States, Ying Cao, Zuo-Jun Max Shen

This work provides a robust approach for the quantile regression problem under a data-driven environment. In contrast to the convention which assumes the samples are i.i.d., we consider a fixed-design setting of the covariates, which fits the real-life applications better. This work proposed a two-step distributionally robust approach with a simple and practical solution. Finite sample performance guarantees and asymptotic consistency are also developed under mild conditions.

4 - A 1.79-approximation Algorithm for a Continuous Review Lost-sales Inventory Model

Linwei Xin, University of Chicago, Chicago, IL, 60637, United States, Linwei.Xin@chicagobooth.edu

Single-sourcing lost-sales inventory systems with lead times are notoriously difficult to optimize. Following Remain (2004), we consider a single-item continuous review lost-sales inventory model with lead times and Poisson demand. We study the performance of a so-called capped base-stock policy. Recent numerical experiments have suggested that such a policy demonstrates superior performance compared with many existing heuristics. In this work, we provide a theoretical foundation for this phenomenon and prove that this policy has a worst-case performance guarantee of 1.79.

■ TE19

CC- Room 307

Behavioral Health Care

Sponsored: Behavioral Operations Management

Sponsored Session

Chair: Robert Batt, Wisconsin School of Business, UW-Madison

1 - The Effects of Performance Pay on Discretionary Task Sequence, Learning and Performance

Maria R. Ibanez, Northwestern University, Evanston, IL, 60208, United States

Analyzing records of millions of radiological diagnoses from doctors working across the US, we investigate how performance pay induces workers to work not only harder but also smarter—learning how to be more productive and to sequence their work better.

2 - Text and Visual Analytics Versus Thematic Analysis of Medical Residents' Responses to Questions Regarding Hand-hygiene and Infection Control

Reidar Hagtvedt, University of Alberta School of Business, Edmonton, AB, Canada, hagtvedt@ualberta.ca, Devika Dixit, Lorraine M. Thirsk, Trish Reay, Kenneth L. Schultz, Gregory Jones, Sarah Forgie

We investigate if newer text analytics tools will lead to different results than a traditional thematic analysis, specifically using structured interviews in the area of infection control and hand-hygiene. A dataset from medical residents at a tertiary hospital provides the setting, with a published qualitative analysis. A novel social network algorithm is then applied to discover potential further detail in the data.

3 - Turnover Among Part-Time Nursing Aides: Scheduling Smarter

Kevin Mayo, Indiana University, Bloomington, IN, 47408, United States, Eric Michael Webb, George Ball, Kurt Bretthauer

Extremely high turnover rates among part-time nurse aides can have significant negative effects on patient outcomes. We examine 6,634 part-time nurse aides and 5,305 turnovers to determine how scheduling affects turnover. We identify the turnover impacts of the amount and variation of scheduling, along with the effects of co-worker consistency, providing managerial insights to reduce turnover.

4 - What's Next?: Task Sequencing in the Emergency Department

Robert Batt, Wisconsin School of Business, UW-Madison, Madison, WI, 53706, United States

We examine the task sequencing behavior of emergency department physicians. We also propose and analyze several task sequencing heuristics with to determine their impact on length of stay and throughput.

■ TE20

CC- Room 308

Students' Professional Skills Development and Assessment

Sponsored: Education

Sponsored Session

Chair: Sadan Kulturel-Konak, Penn State Berks, Reading, PA, 19610, United States

1 - Integrating Creative Problem Solving Techniques into Engineering and Technology Classes

Sadan Kulturel-Konak, Penn State Berks, Tulpehocken Road, Reading, PA, 19610, United States, sadan@psu.edu, Abdullah Konak

There are different methods suggested in the literature to help students develop creative problem solving abilities. In this study, we will first explain how we integrate creative problem solving modules into undergraduate engineering and technology classes (design and capstone). Then, we will present our findings on how those students find these modules affecting them being more innovative in their class projects based on empirical data.

2 - Teamwork Attitude Differences Between Online and Face-to-face Students

Abdullah Konak, Penn State Berks, Tulpehocken Road, Reading, PA, 19610, United States, konak@psu.edu, Sadan Kulturel-Konak

Challenges of virtual teams may result in negative attitudes toward teamwork and adversely affect students' experiences with online classes. We compare online and face-to-face students' attitudes toward teamwork, their interest in learning their teamwork skills, and teamwork self-efficacy based on an empirical study. The analyses showed that students in online classes had negative attitudes towards teamwork compared to students in face-to-face settings although students in online classes have a higher level of interest in and self-efficacy of teamwork.

3 - Assessment of Students' Creativity

Gul Kremer, Iowa State University, 2529 Union Drive, 3004 Black, Ames, IA, 50011, United States

Science, Technology, Engineering and Mathematics (STEM) fields are applied fields that benefited from the creativity of individuals. Given the complexity level of contemporary problems, continuation of a prepared workforce that is skilled in creative problem solving is very important. However, studies have found that STEM fields, specifically engineering, might be perceived to be "uncomfortable" for some students. Findings such as this have also been suggested as concerns for recruitment and retention of capable students in these fields. This is problematic because science and engineering graduates are among the important innovation drivers as noted in the Global and European Innovation reports. Studies have also shown that a potential exists through pedagogical approaches to counter negative sentiments on the part of students, specifically in design-focused courses, by allowing students to be creative and to further stimulate their creativity. The presentation will summarize a series of studies undertaken to examine the extent to which creativity is covered in the engineering classrooms, and how it has been assessed.

4 - Examining Mentoring Practices in STEM

Joi-Lynn Mondisa, Assistant Professor, University of Michigan, Ann Arbor, MI, United States, jmondisa@umich.edu

Mentoring can be a mechanism that aids in diversifying who participates and persists in STEM fields. Mentors provide emotional, psychosocial, and career support which can help protégés persist in their chosen STEM disciplines. Thus, mentoring can support the production of future engineers. Unfortunately, minimal research studies exist that examine the mentoring approaches, practices, and interactions that occur in underrepresented minority STEM mentoring relationships. In this session, I will discuss findings from my research that examines the individual experiences of exemplar African-American STEM mentors and their mentoring practices with their African-American protégés.

■ TE21

CC- Room 309

Risk Management in Supply Chains

Sponsored: Manufacturing & Service Oper. Mgmt/iFORM

Sponsored Session

Chair: Mert Hakan Hekimoglu, Rensselaer Polytechnic Institute, Troy, NY, 12180, United States

1 - Mitigating Supply Chain Risks and Uncertainty Through On-demand Distribution Systems

Kaan Unnu, Rensselaer Polytechnic Institute, Center for Industrial Innovation, Troy, NY, 12180-3590, United States, unnuk@rpi.edu, Jennifer A. Pazour

Traditionally, companies have responded to fast delivery requests by storing a larger diversity of products in a broader distribution network by increasing the number and capacity of their distribution locations. Considering today's demand uncertainty and volatility, this approach possibly leads to underutilized or under-capacitated distribution centers and additional cost risks. However, on-demand distribution systems enable another option which creates flexibility and provides new directions for cost-effective improvements. These systems offer unique advantages and create new dynamics that require new knowledge and methods for the design and operations of distribution networks.

2 - When Are Retailer's Instruments to Induce Higher Supplier Social Responsibility Level Effective?

Haiying Yang, Syracuse University, Syracuse, NY, United States, hyang20@syr.edu, Zhengping Wu

Different instruments (e.g., cost subsidy) have been used in practice by retailers to induce improved social responsibility level of their upstream. We use principal-agent theory to explain how retailers design contract menus to motivate suppliers to truly report production cost after suppliers' decision of social responsibility level. We examine parametric conditions under which such measures are effective.

3 - React or Wait? Optimal Response to Disruptions and the Role of Disruption Monitoring

Shailesh Divey, Rensselaer Polytechnic Institute, Troy, NY, 12180, United States, diveys@rpi.edu, Mert Hakan Hekimoglu, T. Ravichandran

This study examines the benefits of AI- and cloud-based platforms (e.g, IBM's Watson Supply Chain, Elementum) that enable real-time monitoring of events like supply chain disruptions, and how such monitoring capabilities influence firms' optimal response strategies to resolve the uncertainty associated with the length of these disruptions. Using a multi-stage stochastic program, we show that real-time monitoring capabilities offer the flexibility of revising the firm's initial response to a disruption in real time while the event continues to unfold.

4 - Mitigating Disruption Risks in Delivery Supply Chains to Serve Contracted Customers

Mert Hakan Hekimoglu, Rensselaer Polytechnic Institute, Pittsburgh Building, Troy, NY, 12180, United States, hekimm@rpi.edu, John H. Park, Burak Kazaz

Motivated by a Fortune 150 company, this paper helps a firm determine its capacity expansion decisions as a mitigation strategy against disruptions in a delivery supply chain. We formulate the firm's capacity planning problem using a two-stage stochastic model. The firm determines the capacity expansion amount in each fulfillment center in stage 1. If a disruption occurs in stage 2, then the firm determines the optimal allocation of the backup capacity in order to satisfy the orders arriving at the disrupted fulfillment center. The firm restricts the probability of the number of late deliveries exceeding a tolerable threshold under risk aversion that we define as service-at-risk.

■ TE22

CC- Room 310

Sustainability Practices in Supply Chains

Sponsored: Manufacturing & Service Oper. Mgmt/Sustainable Operations

Sponsored Session

Chair: Gokce Esenduran, Purdue University, West Lafayette, IN, 47907, United States

1 - Implementing Environmental and Social Responsibility Programs in Supply Networks Through Multi-Unit Bilateral Negotiation

Chengzhang Li, Purdue University, West Lafayette, IN, 47907-2056, United States, Annabelle Feng, Mengshi Lu, George Shanthikumar

We study ensuring environmental and social responsibility (ESR) in general supply chain networks through multi-unit bargaining. We derive the equilibrium negotiation outcome, which captures the imbalance of the bargaining power in the supply chain, and demonstrate its advantages over existing approaches. We also investigate the initiator's preferred implementation structure and various extensions including multiple ESR effort levels, sequential formation of ESR relationships, and multiple ESR programs.

2 - Sustainability in Fashion Industry: A Case for On-demand Production

Adem Orsdemir, University of California-Riverside, Riverside, CA, 92521, United States, orsdemir@ucr.edu, Aydin Alptekinoglu

In recent years, fashion industry has been identified as the one of the biggest polluters of the environment. Several fashion retailers, including Burberry, H&M and Nike, have been accused of burning their left-over inventory. In fact, Burberry has admitted to doing so. Thus overproduction is one of the fundamental sustainability issues in fashion. To tackle the overproduction problem, on-demand customized production is suggested as one of the remedies. In this research, we characterize when on-demand customized production indeed reduces the environmental impact of fashion industry.

3 - Manufacturer's Voluntary Environmental Efforts under Product Ban Uncertainty

Wenli Xiao, University of San Diego, San Diego, CA, 92110, United States, wenlixiao@sandiego.edu, Ximin (Natalie) Huang, Aditya Vedantam

We study a manufacturer's voluntary environmental efforts as a preemptive strategy against potential regulatory action to ban future sales of the product. The manufacturer can exert voluntary efforts by increasing the product's recycling rate and develop a substitute product, to influence the regulator to reduce the level of product ban. We show how the potential for a future product ban impacts the manufacturer's recycling rate decision on an existing product and its effort to develop a greener substitute product. In addition, we provide the insights of how the manufacturer can influence the regulator to relax the strictness of a product ban.

4 - Laissez-Faire versus Intervention: Implications of Regulation Preventing Unauthorized Remanufacturing

Minyue Jin, Chongqing University, Chongqing, China, minyuejin@cqu.edu.cn

To ensure that remanufactured products are as good as new, the Chinese government enacted regulations to prevent unauthorized remanufacturing, i.e., independent remanufacturers (IRs) are not allowed to carry out remanufacturing unless they obtain authorization from original equipment manufacturers (OEMs). While in the US, this kind of regulation does not exist. This regulation seems benefit the OEMs but hurt the IRs because it enables OEMs to prevent unauthorized remanufacturing. We find that the OEM benefits from this regulation. However, the regulation could also benefit the IR. The reason is that free opportunity of unauthorized remanufacturing can cause a prison's dilemma to the OEM (IR).

■ TE23

CC- Room 3A

Simulation-Supported Decision-making in Healthcare

Sponsored: Decision Analysis

Sponsored Session

Chair: Aditya Umesh Kulkarni, Virginia Commonwealth University, Glen Allen, VA, 23059, United States

Co-Chair: Christian Wernz, Virginia Commonwealth University - VCU, Richmond, VA, 23298, United States

1 - Assessing the Impact of Emergency Department Admissions for Grey Area Patients

Sebastian Alvarez Avendano, University of Wisconsin-Madison, Madison, WI, United States, alvarezavend@wisc.edu, Amy Cochran, Brian Patterson, Gabriel Zayas-Caban

Often, it is assumed that the decision to admit a given patient is based on black and white clinical factors. While this is true in some cases, many patients fall into a gray area without clear evidence-based guidelines suggesting admission or discharge as the best course of care. Using observational data, we seek to determine to what extent admissions impoves outcomes for a specific "gray area" patient population: elderly patients in the emergency department presenting with chest pain.

2 - Appointment Scheduling in Primary Care with Recurring Visits

Hari Balasubramanian, Univ of Massachusetts-Amherst, Amherst, MA, 01003, United States, hbalasubraman@ecs.umass.edu, Prashant Meckoni

Traditional queuing systems schedule incoming customers in a queue waiting for service according to some predefined policy—including first in first out (FIFO), shortest job first, or priority queuing. Appointment based schedules used in many primary health care providers follow a different queuing policy. Patients may schedule their appointment several weeks ahead of their desired date. Early scheduling may fill up all slots up to a day much in advance, and may restrict other patients needing those slots at a shorter timeline. Using a simulation model, we explore the use of reservations in handling patients who frequently need to see their doctor at a short notice as compared to most other patients.

3 - Surgical Capacity Allocation via Simulation: The Case of Breast Surgery

Derya Kilinc, Arizona State University, Tempe, AZ, United States, Derya.Kilinc@asu.edu, Narges Shahraki, Kalyan Pasupathy, Esma S. Gel, Amy Degnim, Mustafa Y. Sir

The breast surgical practice at Mayo Clinic, Rochester has experienced an increase in the number of patients with complex conditions in recent years. This caused longer patient care delays and increased workload for the existing resources. We develop a decision tree model to characterize the demand complexity and a simulation tool to quantify the relationship between patient demand (volume, complexity, and trend) and capacity utilization and measure its effect on patients waiting time. Our simulation tool can be utilized to accurately predict and plan the capacity to avoid prolonged waiting times in providing care.

4 - A Simulation Optimization Approach to Real-time Behavioral Therapy in the Medication Assisted Treatment Model of Care

Carolina Vivas-Valencia, Purdue University, West Lafayette, IN, 47906, United States, Nan Kong, Yunan Liu, Paul Griffin

Medication-Assisted Treatment (MAT) is an approach that can be combined with behavioral therapy to treat substance use disorders. Behavioral therapy may help improve adherence to MAT; however, resources such as professional counseling personnel, are not always available. Volunteers can be recruited as peer recovery coaches in this model of care to provide behavioral therapy via an online platform. We develop a simulation-optimization approach to support this and present management insight into emerging digital technology for efficient therapy delivery.

5 - Data-calibrated Agent-based Simulation for Electronic Health Record Downtime Contingency Planning

Christian Wernz, Virginia Commonwealth University, Richmond, VA, 23298, United States, Aditya Umesh Kulkarni, Ethan Larsen, Carlos Rivera, Raj Ratwani

Developing effective Electronic Health Record (EHR) downtime contingency plans for hospital staff is an important challenge for healthcare organizations, but testing such a plan is difficult in practice. Based on real-world data collected at a hospital, we constructed an agent-based model of their emergency department and clinical laboratory. By simulating the agent-based model, we evaluated the effectiveness of different contingency plans to compare their performance and identify the best plan. Our approach allows hospitals to develop, test and optimize various EHR downtime contingency plans without disrupting patient care.

■ TE24

CC- Room 3B

Advances in Organizational Decision Quality

Sponsored: Decision Analysis

Sponsored Session

Moderator

Carl S. Spetzler, Strategic Decisions Group, Palo Alto, CA, 94301-2411, United States

Panelist

- James Driscoll, Intel Corporation, Beaverton, OR, 97007, United States
- William K. Klimack, Chevron, Magnolia, TX, 77354, United States
- Yong Tao, Cloudstone, Redwood City, CA, United States

■ TE25

CC- Room 401

Revenue Management, Pricing I

Contributed Session

Chair: Bobby Nyotta, UCLA Anderson School of Management, Valencia, CA, 91355, United States

1 - Product Quality and Quantity with Responsive Pricing

Yanjun Wang, University of Science and Technology of China, Hefei, China

We study a firm's joint product quality and quantity decisions when the firm uses responsive pricing policy. Consumers differ in two dimensions: quality valuation and reservation utility for the basic product. Quality valuation reflects the intrinsic heterogeneity of consumers and is, hence, always unknown to the firm. Reservation utility is affected by extrinsic market conditions and can, hence, be updated after production. We find that as reservation utility increases or quality valuation decreases, the optimal quantity increases and, counterintuitively, the optimal quality decreases. Furthermore, the firm might not be willing to expand its product line even if given an option to do so.

2 - Randomized Pricing with Consumer Stockpiling

Burak Gokgur, Asst. Prof., Sabanci University, Istanbul, Turkey, bgokgur@sabanciuniv.edu, Selcuk Karabati

We consider a retailer with customers that are heterogeneous along the product valuation and storage capacity dimensions. The retailer's objective is to maximize the expected revenue with a randomized pricing strategy. We discuss the conditions when randomized pricing strategy serves as an intertemporal price discrimination mechanism, and, through a numerical study, we quantify its impact on revenue.

3 - Development of Collaborative Consumption Pricing: An Econometrics Model Approach of Airbnb

Funda Sarican, PhD Student, Bentley University, Boston, MA, United States, fsarican@bentley.edu

On one hand, the sharing economy provides new opportunities on the other hand, it is also raising several issues as more incidents arise concerning bypassing laws. More and more well-known sharing economy companies such as Airbnb, and Uber are struggling against regulation. In order to deal with issues such as consumer and supplier safety, and competitive fairness, some of the cities has begun to practice regulations. The aim of this paper is to determine the effect of these regulations on pricing. In this paper, I apply Difference-and difference (DD) method to identify causal effect and remove unobservable factors that vary in time and listing/room level.

4 - Capacity and Pricing Optimisation in the Presence of Ancillary Items

John G. Wilson, Ivey Business School, London, ON, Canada, jwilson@ivey.ca

Many applications exist where ancillary products are sold with a primary item. E.g., warranties is often offered to those who buy television sets. This has become even more important in the airline industry where ancillary products such as baggage fees have become vital to the financial health of the industry. The question of what price to charge for the primary and ancillary products will be investigated. We look at the optimal assignment of capacity, e.g., the size of an aircraft to assign to a particular route. It is shown that the optimization of prices when demand functions are linear reduces to the solution of a system of linear equations and the optimization of a one variable function.

5 - Dynamic Pricing of Reusable Resources: Experiments, Estimation, and Optimization of On-street Parking

Bobby Nyotta, UCLA Anderson School of Management, Los Angeles, CA, United States, bobby.nyotta.1@anderson.ucla.edu, Fernanda Bravo, Keith Chen

Motivated by dynamic pricing of on-street parking, we analyze a general framework to determine the optimal prices in a system with multiple zones where each zone contains a finite number of reusable resources. We consider a demand model with imperfect substitution, where a price increase for one zone may lead customers to use a different, adjacent zone. First we develop a pricing model to determine optimal set of prices. Second, using real data from a natural pricing experiment in a large metropolitan city, we estimate price and spatial elasticities.

■ TE26

CC- Room 4C-1

Economic Impact

Contributed Session

Chair: Suning Zhu, Trinity University

1 - Mergers Between On-demand Service Platforms: The Impact on Consumer Surplus and Labor Welfare

Tao Lu, Rotterdam School of Management, Erasmus University, Rotterdam, Netherlands, lu@rsm.nl, Xiaogang Lin, Xin Wang

We study two on-demand service platforms competing in a two-sided market in which customers are waiting time-sensitive and agents provide service based on expected earnings. While a merger reduces competition, we show that customers may benefit from a merger due to the risk-pooling effect; moreover, if customers are sufficiently sensitive to delay, this benefit can spill over to the labor force via cross-side network externalities. We further establish that a win-win-win outcome, in which merging firms, customers and agents are all better off, can be achieved if the merged platform commits to certain ratios between prices and wages.

2 - Studying Quantity Discount and Market Share Contracts under Congestion

Sumanta Singha, Indian School of Business, Hyderabad, India, sumanta_singha@isb.edu, Rajib L. Saha, Subodha Kumar

Unlike in quantity discount contracts, discount can be based on the share of demand the buyer allocates to the seller; typically known as market share contract. We study and compare the optimal decisions of a buyer and a strategic seller under both types of contracts given the demand is congestion sensitive.

3 - A Longitudinal Investigation on Economic Impact of Organizational Big Data and Analytics Implementation

Suning Zhu, Trinity University, San Antonio, TX, United States, Jiahe Song

This study investigates the impact of three aspects of big data and analytics (BDA) implementation (i.e., BDA implementation scope, frequency, and objective) on firm profitability. In addition, we examine the role of BDA human competency in moderating the economic impact of BDA implementation. To perform credible causal evaluation, we construct a panel data set by collecting related information about enterprise BDA and profits from major news sources, Compustat database, and Linkedin between 2010 and 2018. This study contributes to knowledge-based view, complementary theory, and BDA literature. Practical insights from this research are generated for decision makers looking to implement BDA.

4 - Logistics Service Sharing in Dual-online-Channel Supply Chain

Ping He, South China University of Technology, Guangzhou, China, Shanshan Zhang

Logistics service sharing (LSS) becomes increasingly common in E-commerce. We study the impact of LSS on a dual-online-channel supply chain composed of a retailer (LSS provider) and a manufacturer (potential LSS receiver). We find that higher competition intensity level stimulates the retailer to condense delivery lead time without LSS, but to prolong it with LSS. There exists a decision space to let the two firms Pareto improved, but it shrinks a lot if the competition intensity level is relatively high. Furthermore, the social welfare may be decreased with LSS even when the two firms are Pareto improved.

5 - Mining Public Perception – Blockchain-based Services in Mainstream Media

Christopher Grossmann, EBS Universitaet fuer Wirtschaft und Recht, Wiesbaden, Germany, christopher.grossmann@gmail.com, Katrin Merfeld, Sven Henkel

Despite the media hype and increasing market penetration of blockchain-based services, adoption happens slowly outside the universe of cryptocurrency, and blockchain enthusiasts. Actual customer perception remains uncertain and despite the technology's objective benefits, first insights suggest that customers developed negative associations. To exploit blockchain-based features for overcoming adoption barriers of services, adequate communication is essential. This paper provides an overview of the past and current connotation of blockchain-focused news articles by applying a multi-perspective text mining approach.

■ TE27

CC- Room 4C-2

Empirical Research in Retail Operations

Sponsored: Service Science

Sponsored Session

Chair: Hyun Seok (Huck) Lee, College of Business, Oregon State University, Corvallis, OR, 97330, United States

1 - M-commerce, Sales Concentration, and Inventory Management

Tom Fangyun Tan, Southern Methodist University, Dallas, TX, 75275, United States, ttan@cox.smu.edu, Nitish Jain

We examine the differences in primary online channels - mobile and PC - on shaping sales concentration across products and the cost of ignoring such a difference on inventory management, a core decision for operations managers. We identify the mobile channel's effect on sales concentration using a difference-in-differences strategy that leverages a quasi-experiment stemming from the retailer's decision to discontinue its PC sales channel. We find that the mobile channel increases the share of popular products by 5% as compared with the PC channel. We also identify scenarios where ignoring this significant sales concentration difference will yield sub-optimal inventory stocking by 6.1% to 17.7%.

2 - An Investigation of Peer Effects on Grocery Store Check-out Productivity

Hyun Seok (Huck) Lee, College of Business, Oregon State University, Corvallis, OR, 97330, United States, HyunSeok.Lee@oregonstate.edu, Guanyi Lu, Junbo Son

Using an operational data set in a grocery store setting, we examine how a cashier's productivity level affects other cashiers' performance. Contrary to the literature which suggests positive peer effects in retailing setting, we find employees tend to reduce their efforts (i.e., free-riding) when working with productive peers. In addition, full-time employees reduce their efforts more than part-time employees. Using an alternative measure, we find more experienced employees (hours worked) free-ride more than less experienced employees. We propose suggestions for retailers to address this issue.

3 - Execution Failures in Supply Chains - A Virtual Reality Experiment

Nicole DeHoratius, University of Chicago, 15345 SW Lark Lane, Beaverton, OR, 97007, United States

We conduct a real-effort experiment in a virtual reality context to explore key drivers of execution failures in retail supply chains. We find task intensity and task complexity impact worker output and accuracy. We test the impact of product/packaging design changes on task performance.

4 - The Reference Effect of Delay Announcements: A Field Experiment

Qiuping Yu, Georgia Institute of Technology, Atlanta, GA, 47405-1701, United States, Gad Allon

We explore whether customers are loss averse in time and how delay information impacts such reference-dependent behavior via a field experiment at a call center. Customers are provided with delay announcements or no announcements in a quasi-randomized manner in our field experiment. We show that customers are loss averse regardless of the announcements, (especially when the waiting time is relatively long). While delay announcements do not alter the fact that customers are loss averse, they may facilitate more granular learning of the offered waiting time and thus impact the reference point. Through counterfactual studies, we demonstrate the managerial implications of our behavioral insights.

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Özgür Gürerk

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Achal Bassamboo

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6 - Execution Failures in Supply Chains – A Virtual Reality Experiment

Dorothee Honhon, Kyle Hyndman

We conduct a real-effort experiment in a virtual reality context to explore key drivers of execution failures in retail supply chains. We find task intensity and task complexity impact worker output and accuracy. We test the impact of product/packaging design changes on task performance.

■ TE28

CC- Room 4C-3

Transform Healthcare and Retail through Analytics

Sponsored: Service Science

Sponsored Session

Chair: Seokjun Youn, The University of Arizona, Texas A&M University, College Station, TX, 77840-4217, United States

1 - Can Information Technology Improve Inter-generational Health Outcomes of Mothers and of Babies?

Min Chen, Florida International University, Miami, FL, United States, mchen2@fiu.edu, Monica Chiarini Tremblay, Rajiv Kohli

While information technology (IT) holds great promise for improving the quality and efficiency of care and for lowering the health care costs, it is far from certain whether and how electronic health records improve maternal and infant well-being and lower future risk in outcomes. This study constructs a unique dataset that includes rich information about medical interventions as well as a battery of maternal and birth outcomes to investigate the effect of electronic health records in the context of intergenerational health.

2 - Identifying Determinants of Market Share of Specialists: Empirical Investigation

Lavlin Agrawal, State University of New York-Buffalo, Buffalo, NY, 14228, United States, Saeede Eftekhari, Niam Yaraghi, Ram Gopal, Ramaswamy Ramesh

This study is focused on identifying the factors which impact the market share of specialists in terms of patients they receive from other specialists and primary care physicians. We apply econometric analysis to model the patient share of specialists using three categories of variables: competition variables which pertain to availability of the physicians with the same specialty in the area, supply variables which pertain to availability of the physicians who can serve as patients suppliers for the specialists, and physician variables which pertain to the attributes of physicians. The findings of this study has significant implication for health policy makers and healthcare providers.

3 - Does Sharing Make My Data More Insecure? An Empirical Study on Health Information Exchange and Data Breaches

Leting Zhang, Temple Universisty, Philadelphia, PA, 19122, United States, Min-Seok Pang, Sunil Wattal

This paper examines the security implications of participation in inter-organizational systems (IOS) in the context of the healthcare industry. Specifically, we ask - how does joining in a Health Information Exchange (HIE) affect hospitals' data breach risks? We study this issue using a six-year panel data from multiple sources on HIE participation and data breaches. Our results show that joining in an HIE decreases a hospital's probability of a data breach. We also find that this mitigation effect is stronger for hospitals with a higher IT security capability. Surprising, a higher HIE participation rate also lowers the risks in hospitals that are not in the HIE in the same region.

4 - How Customers Choose Among Different Products: Organic, Conventional, and Other Attributes

Zhihao Zhang, University of South Carolina, Columbia, SC, 29033, United States, Sriram Venkataraman, Yan Dong, Mark Ferguson

Using scanner panel data retailers, we examine how customers choose between different attributes of organic and conventional products. In particular, we estimate own-price and cross-price elasticities under different nesting options. Further, we estimate own-elasticity of different variables.

■ TE29

CC- Room 4C-4

Joint Session AMD/Practice Curated: Signaling in Auctions

Sponsored: Auction and Market Design

Sponsored Session

Chair: Olivier Bos, Pantheon-Assas University

1 - Optimal Auction with Signaling Concerns

Olivier Bos, Pantheon-Assas University, Paris, 75006, France, Martin Pollrich, Tom Truyts

We study optimal auctions in a symmetric private values setting with signaling. Every bidder cares about winning the object, but also about an outside observer's inference on her own type. The signaling motive leads to a failure of revenue equivalence. We determine the optimal auction for concave and convex bidders' utilities when they care only about the statistical mean of the observer's inference. For the special case that bidders' utilities depend linearly on the outsider's inference we prove revenue equivalence for auctions with entry fees. Entry fees allow the designer to extract the signaling value of every bidder and thus restores revenue equivalence.

2 - Price Effects of Supply and Demand in Multi-unit Auctions with Affiliated Values

Marion Ott, ZEW, Templergraben 64/V, Mannheim, 52062, Germany, Karl-Martin Ehrhart

We vary the number of units and bidders in multi-unit auctions with affiliated values and single-unit demand. The sampling effect of the signals and the winner's curse correction in the bids have opposed influence on the expected price per unit. In a uniform-price auction with common values and affiliated signals, the expected price per unit increases in the number of units, and, unless there are no more than twice as many bidders as units, also in the number of bidders. Thus, for large numbers of bidders both changes increase the price whereas for low numbers of bidders both changes influence the price in the opposed direction than in the pay-as-bid auction.

3 - VCG, the Core and Assignment Stages in Auctions

Oleg V. Baranov, University of Colorado-Boulder, Boulder, CO, 80309, United States, oleg.baranov@colorado.edu, Lawrence M. Ausubel

The Vickrey-Clarke-Groves (VCG) mechanism is one of the most compelling constructs in mechanism design, but the presence of complementarities creates the theoretical possibility of non-core outcomes. In this paper, we empirically document such outcomes—including three zero-revenue rounds—in the Federal Communications Commission (FCC) Incentive Auction. We then model the two-stage approach commonly used for auctioning spectrum, where bidders bid first for generic blocks and then bid for specific frequencies. We demonstrate that this approach may induce complementarities in the second stage even when the underlying preferences are well-behaved.

4 - Cheap-Talk Communication in Procurement Auctions

Sander Onderstal, University of Amsterdam, Amsterdam, Netherlands

In procurement auctions, the buyer may include a dialogue in the procurement procedure in which it enables the bidders to reveal information that will help the buyer to better specify the terms of the contract. However, a potential downside of such procedure is that the bidders have incentives to manipulate the information they provide as it boils down to 'cheap talk'. This raises questions like: When do buyers benefit from non-binding communication between them and the bidders? When should buyers only allow the winner of the auction to communicate and when should they allow several bidders to communicate before the auction? We address these questions both theoretically and in laboratory experiments.

5 - Subcontracting Requirements and the Cost of Government Procurement

Benjamin Rosa, Virginia Tech, Blacksburg, VA, United States, brosa@vt.edu

I study how subcontracting requirements for the utilization of disadvantaged firms affect procurement auctions using data from New Mexico's Disadvantaged Business Enterprise Program. Theoretically, subcontracting requirements reduce prime contractors' private information on their costs by requiring them to select their subcontractors from a common pool of disadvantaged firms. This feature mitigates subcontracting cost increases by causing prime contractors to strategically lower their markups. I find that New Mexico's past subcontracting requirements led to a minor procurement cost increase.

■ TE30

CC- Room 6A

Grant and Development Programs on Diversity, Equity, and Inclusion

Sponsored: Diversity, Equity, and Inclusion

Sponsored Session

Moderator

Shengfan Zhang, University of Arkansas, Department of Industrial Engineering, Fayetteville, AR, 72701, United States

In this session, we aim to introduce and promote initiatives on Diversity, Equity, and Inclusion at various funding agency and organizations. We also hope to create a dialogue between the funding agency, program organizers, and future participants. Our panelists include Dr. Jessie DeAro, Program Director for the NSF ADVANCE program, Dr. Christine Grant, Associate Dean of Faculty Advancement at North Carolina State University, and Dr. Eve Riskin, Associate Dean of Diversity and Access and Faculty Director of the ADVANCE program at University of Washington.

Moderator

Julie Simmons Ivy, North Carolina State University, Raleigh, NC, 27695-7906, United States

Panelists

- Jessie DeAro, National Science Foundation, Alexandria, VA, United States
- Christine Grant, North Carolina State University, Raleigh, NC, United States
- Eve Riskin, University of Washington, Seattle, WA, United States

■ TE31

CC- Room 6B

Enterprise-level and Concept-driven Studies for Defense

Sponsored: Military and Security

Sponsored Session

Chair: Trevor Bihl, Air Force Research Laboratory, Beavercreek, OH, 45434, United States

1 - Defense Enterprise Modeling

Mark A. Gallagher, Air Force Institute of Technology, Columbus, OH, 43229-5535, United States, markgallagherJMJ@gmail.com, Franco Villongco

We explore modeling at the Defense Enterprise level, where decisions regarding military strategy and force structure across all military services as well as against various scenarios and conditions are of primary concern. In particular, we characterize uncertainty, adversarial, and multiobjective aspects that contribute to the complexity of decision making at the Defense Enterprise level. We survey current analytic models that support decision making within this context and define a future research path that has significant potential to mitigate current analytical challenges.

2 - Developing a Taxonomy of Planning for Autonomous Systems

Trevor Bihl, Air Force Research Laboratory, Beavercreek, OH, United States, Chad Cox, Timothy Machin

This presents a vision of automatic planners as applied to unmanned vehicles, while considering the ultimate goal of full autonomy. Planners are presented as components of a hierarchical, modular automaton with increasingly autonomous capabilities as higher functional modules are added. A technical baseline is developed and several methods are described within a taxonomy, highlighting present research interests, demand signals, and possible gaps in the research. This presentation explores relative strengths and weaknesses and suggests ways that these approaches can complement each other. Important topics of research are suggested.

3 - Readiness Modeling: Changing the Question From "Ready or Not?" to "Ready for What?"

Shaun Doheney, Chair, Resources & Readiness Applications, ProbabilityManagement.org, Washington, DC, United States, shaun@probabilitymanagement.org, Sam Savage, Connnor McLemore

Military readiness is expensive in terms of financial costs, time, and military risk, and is usually perishable. While improved readiness accounting will likely be an evolutionary process with inputs from numerous stakeholders, Operations Research analysts are well suited to recommend some key features for an improved military readiness representation framework that is useful, logically consistent, and most importantly is simple enough for incremental adoption by senior military leaders. In this talk, we provide working prototypes of models to demonstrate some of the underlying principles associated with this new readiness representation approach.

■ TE32

CC- Room 6C

Dynamic Programming/Control

Contributed Session

Chair: Duan Li, City University of Hong Kong, School of Data Science, College of Business, Kowloon, Hong Kong

1 - Optimal Traffic Allocation Policy in Dynamic Contracts

Chong Zhang, Tsinghua University, Beijing, China, zhangch.14@sem.tsinghua.edu.cn, Yong Liang, Peng Sun, Runyu Tang

Motivated by practices that platforms such as Taobao, Ele.me, and Toutiao utilize credit points system to connect adverse events caused by the agents (i.e., product/service/content providers) on them with the agents' ranking in the end users' search results, we focus on a principal-agent problem about traffic allocation in dynamic contracts. In particular, we study how the principal should create contractual incentives to encourage effort from agents to reduce the chance of adverse events by traffic allocation. We characterize the optimal traffic allocation policy of the single-agent case and also explore the heuristic policy of multi-agents case.

2 - Resource Allocation in Non-profit Settings- Approximate Dynamic Programming Approach

Faisal A. Alkaabneh, Cornell University, Ithaca, NY, United States, fma34@cornell.edu, H. Oliver Gao

We study stochastic resource allocation decisions in the context of non-profit settings. We formulate the problem as a stochastic dynamic program and develop an approximate dynamic programming framework to generate high-quality solutions. We use real-data obtained by one of the food banks in New York State to demonstrate the performance of the approach. More specifically, our algorithm demonstrates %5.0 improvement in total utility against the policy implemented in practice; furthermore, when compared against the offline algorithm, the optimality gap is less than %6.0.

3 - The Optimal Nonmyopic Gambling Strategy under a More Generalized Kelly Criterion

Christopher M. Rump, Associate Professor, Bowling Green State University, Bowling Green, OH, United States, cmrump@bgsu.edu

We examine the optimal gambling strategy for a sequence of simple "win" or "lose" wagers under a generalization of the Kelly criterion to one of a shifted log utility of terminal wealth. We correct a previous analysis of this problem in the literature, which established a (flawed) nonmyopic optimal policy whose wager is no longer a constant fraction of wealth but, rather, depends on the number of time stages left to play.

4 - Management of Online Server Congestion Using Optimal Demand Throttling

Sandun Perera, College of Business, University of Nevada, Reno, NV, United States, Varun Gupta, Winston Buckley

Bandwidth throttling is widely employed in practice by online-service-providers (OSPs) as a server/network congestion management tool. However, this topic has been largely neglected in the academic literature. To the best our knowledge, this is the first analytical study that aims at achieving an optimal (non-discriminatory) throttling mechanism for bandwidth when user demand is stochastic. Using a dynamic programming (Quasi-Variational Inequality) approach, we show that it is optimal for the OSP to throttle the demand whenever it reaches a threshold level and downgrade the service speed by a fixed factor while the throttling is employed.

5 - The Optimal Length of a Break

Thomas A. Weber, Professor of Operations, Economics and Strategy, EPFL, Lausanne, Switzerland, thomas.weber@epfl.ch

Assuming a decreasing attention level during (uniform) content delivery and an increasing attention level during a break, this paper examines problem of finding the length of a break so as to maximize the knowledge defined as the area under the attention curve during a predefined time of content delivery. Depending on the length of the delivery horizon and the initial attention level, classes may optimally start with a break or feature multiple breaks, approaching a limit cycle in the limit. The latter can be calibrated to various periodic resting processes in nature. The underlying optimal control problem is solved using the Pontryagin maximum principle.

6 - Progressive Hedging Algorithm and Bayesian Reinforcement Learning

Duan Li, Professor, City University of Hong Kong, Kowloon, Hong Kong, dli226@cityu.edu.hk, Xin Huang, Daniel Zhuoyu Long

Stochastic control with both inherent random system noise and lack of knowledge on system parameters constitutes a fundamental challenge in reinforcement learning, especially under non-episodic setting. We propose a novel two-layer solution scheme to separate reducible system uncertainty from irreducible one at two layers (by adopting time-composition based DP at the lower layer and the scenario-decomposition based progressive hedging algorithm at the upper layer) and to approximate the optimal policy directly. Applications in dynamic portfolio selection will be discussed.

■ TE33

CC- Room 602

Novel Techniques in Computational LP/MILP

Sponsored: Optimization/Computational Optimization and Software

Sponsored Session

Chair: Menal Guzelsoy, SAS, Cary, NC, 27513, United States

Co-Chair: Imre Polik, SAS Institute, Inc., Cary, NC, 27513, United States

1 - Excluded Solutions Presolve Technique for Mixed-integer Linear Programming

Menal Guzelsoy, SAS Institute, Inc., 100 SAS Campus Drive, Cary, NC, 27513, United States, Imre Polik

In this talk, we give an overview of SAS/OR MILP presolver and present a new technique and its extensions where we analyze and derive presolve reductions from the solutions excluded by each row.

2 - Strategies for Solving Infeasible Mixed Integer Programs

Ed Klotz, IBM, Incline Village, NV, 89450, United States

Infeasible Mixed Integer Programs (MIPs) often pose a distinct set of challenges for branch and cut algorithms. The absence of a cutoff value established by an integer feasible solution essentially disables certain features of the branch and cut algorithm, making it less effective. However, for MIPs that are suspected to be infeasible, other tactics are particularly effective at proving infeasibility. We will examine some of these and in doing so show how to prove infeasibility for two open MIPLIB 2017 models that, as of this writing, had an unknown feasibility status.

3 - New Features and Enhancements in the SAS Optimization Solvers

Imre Polik, PhD, SAS Institute, Inc, Cary, NC, United States

We present some exciting new features of the SAS optimization solvers including a cloud-ready architecture, a Python interface, several new solver capabilities, new presolver techniques, performance enhancements and future plans.

■ TE34

CC- Room 603

Optimization & Aviation

Contributed Session

Chair: K. Jo Min, Iowa State University, Department of Industrial &, Ames, IA, 50011-2164, United States

1 - Study of Team Mental Models Using Particle Swarm Optimization

Deanna Kennedy, Associate Professor, University of Washington Bothell, Bothell, WA, United States, deannak@uw.edu, Sumati Ahuja

To be effective, members of a team need to be aligned in their individual understanding of the task. In other words, the accuracy and sharedeness of the team mental model affects team performance. Herein, we use particle swarm optimization to model and analyze how interactions between team members lead to team mental model convergence and de-convergence. Implications are discussed.

2 - Iterative Linearized Control: Stable Algorithms and Complexity Guarantees

Vincent Roulet, Postdoc, University of Washington, Seattle, WA, United States, vroulet@uw.edu, Siddhartha Srinivasa, Dmitriy Drusvyatskiy, Zaid Harchaoui

We examine popular gradient-based algorithms for nonlinear control in the light of the modern complexity analysis of first-order optimization algorithms. The examination reveals that the complexity bounds can be clearly stated in terms of calls to a computational oracle related to dynamic programming and implementable by gradient back-propagation using machine learning software libraries such as PyTorch or TensorFlow. Finally, we propose a regularized Gauss-Newton algorithm enjoying worst-case complexity bounds and improved convergence behavior in practice. The software library based on PyTorch is publicly available.

3 - Connectivity Properties of Optimal Decentralized Control

Han Feng, UC Berkeley, Berkeley, CA, United States, han_feng@berkeley.edu

The complexity of optimal decentralized control (ODC) problem is reflected in the properties of its feasible set. We consider the design of a static decentralized controller and show that there is no polynomial upper bound on the number of connected components of the set of stabilizing decentralized controllers. In particular, the number can be exponential in the order of the system for a subclass of problems. Good decentralized structures that have tractable connectivity properties are studied with a combination of Routh-Hurwitz Criterion and Lyapunov stability theory. We further give heuristics to overcome exponential complexity with local search and homotopy.

4 - Evidence-based Graph Model for Analyzing Air Carbon Mitigation Conflict in China

Shawei He, Assistant Professor, Nanjing University of Aeronautics and Astronautics, Nanjing, China, schawae@hotmail.com

Interactions among decision makers in reaction to the implementation of air carbon mitigation policies in China are investigated using Graph Model for Conflict Resolution. The preferences for decision makers are elicited by applying the option prioritization approach based on the results suggested by system analysis models depicting their behaviors. Sensitivity analysis is carried out to discuss scenarios at which the governments implement different air carbon policies. The equilibria indicate guidance of actions for the government on how to smoothly implement carbon mitigation policies in order to achieve emission goals in civil aviation industry in China.

5 - Network Optimization for Hybrid Last-mile Delivery with Trucks and Automated Drones

Taner Cokyasar, PhD Student, University of Tennessee-Knoxville, Knoxville, TN, United States, cokyasar@vols.utk.edu, Wenquan Dong, Mingzhou Jin

Drone delivery systems have recently attracted considerable attention from governments, enterprises, and researchers. They have primarily focused on economic benefits, technological adoption, and sustainability. To extend the service range of drones, autonomous battery swap machines (ABSMs) were invented and adopted by some industries. In this study, we propose a mixed integer non-linear programming model incorporating queueing theory that dedicatedly assigns customers to drone or truck transportation channels and determines optimal ABSM locations minimizing the total transportation cost. We provide linearization and solution procedures to deal with high computational complexity.

6 - Infrastructure Decisions and Policies under Uncertainties in Arctic Regions

K Jo Min, Iowa State University, Ames, IA, United States, jomin@iastate.edu, John Jackman, Zhuoyi Zhao

The arctic regions are faced with natural and human-made, uncertain changes on their infrastructures ranging from villages and cities to roads and bridges to ports and depots. Under such circumstances, based on stochastic optimal control models of diffusion and jump processes, we formulate real options models such as option to construct, expand, contract, mothball, decommission, and/or abandon. From the analytical, numerical, and computational results, we will derive managerial insights and economic implications for the academics and practitioners.

■ TE35

CC- Room 604

Advances in Non-Convex Optimization

Sponsored: Optimization/Integer and Discrete Optimization

Sponsored Session

Chair: Aleksandr M. Kazachkov, QC, H3T1J4, Canada

Co-Chair: Gonzalo Munoz, Montreal, QC, H3T 1N8, Canada

1 - The Convex Hull of a Quadratic Constraint Over a Polytope

Santanu Subhas Dey, Georgia Institute of Technology, School of Industrial and Systems Engineering, Atlanta, GA, 30332, United States, santanu.dey@isye.gatech.edu, Asteroide Santana

We show that the exact convex hull of a general quadratic equation intersected with any bounded polyhedron is second-order cone representable. We present a simple constructive proof of this result.

2 - On the Complexity of Binary Polynomial Optimization Over Acyclic Hypergraphs

Silvia Di Gregorio, University of Wisconsin, Madison, WI, 53715, United States, sdigregorio@wisc.edu, Alberto Del Pia

In this work, we settle the computational complexity of binary polynomial optimization over acyclic hypergraphs. We give a strongly polynomial-time algorithm for -acyclic hypergraphs, and show that for -acyclic hypergraphs the problem is NP-hard. The idea behind our algorithm is to successively remove nest points from the hypergraph, until there is only one node left. Our algorithm can also be applied to any binary polynomial optimization problem that contains -cycles. In this case, the algorithm returns a smaller instance together with a rule to extend any optimal solution for the smaller instance to an optimal solution for the original instance.

3 - Submodularity and Lifting in Nonlinear Optimization with Indicators

Andres Gomez, University of Pittsburgh, Pittsburgh, PA, 15217, United States, agomez@pitt.edu

We propose new classes of valid inequalities for mixed-integer nonlinear optimization problems with indicator variables. The inequalities are obtained by projecting out the continuous variables, exploiting submodularity to derive valid linear inequalities in the space of the discrete variables, and lifting back the inequalities to obtain nonlinear valid inequalities involving both the continuous and discrete variables. The proposed inequalities are shown to describe the convex hulls of many sets involving the mixed-integer epigraphs of quadratic and conic quadratic functions.

4 - Generalized Surrogate Duality for Mixed-Integer Nonlinear Programs

Andrea Lodi, École Polytechnique de Montréal, Montréal, QC, H3T2A7, Canada, Maxime Gasse, Ambros Gleixner, Bemjamin Müller, Gonzalo Muñoz

The most important ingredient for solving mixed-integer nonlinear programs (MINLPs) to global optimality with spatial branch-and-bound is a tight, computationally tractable relaxation. Due to both theoretical and practical considerations, these relaxations are usually required to be convex. Nonetheless, current optimization solvers can often handle a moderate presence of non-convexities efficiently, which opens the door for the use of potentially tighter non-convex relaxations. One way to construct such a relaxation is by aggregating nonlinear constraints of the problem into a single non-convex constraint. The resulting relaxation is called surrogate relaxation, which is similar to the well-known Lagrangian relaxation but provides stronger dual bounds in general. In this talk, we make use of the surrogate dual in a non-convex setting and show the benefits and challenges such relaxation can have in general MINLPs. Additionally, we present a generalization of the surrogate relaxation that allows for multiple aggregations of non-convex constraints. Based on a known Benders-type approach, we present an algorithm that can solve our generalized surrogate relaxation, along with several computational enhancements for improving its practical performance. Finally, we conduct extensive computational experiments on instances of the MINLPLib using the global solver SCIP.

■ TE36

CC- Room 605

Distributionally Robust Optimization: Theory and Applications

Sponsored: Optimization/Optimization Under Uncertainty

Sponsored Session

Chair: Ran Ji, George Mason University, Fairfax, VA, 22030, United States

1 - A Sequential Sampling Method for Distributionally Robust Stochastic Programs

Manish Bansal, Virginia Tech., Blacksburg, VA, 24060, United States, bansal@vt.edu, Harsha Gangammanavar

In this talk, we will present a sequential sampling method to address the two-stage distributionally robust linear programs. A key feature of this method is that it involves assessing the relevance of additional observations in determining the worst-case distribution from the set of probability distributions that is approximated with increasing information on uncertainty. We will provide conditions under which this algorithm is convergent and results of our computational experiments to evaluate the performance of this method.

2 - Distributionally Robust Combinatorial Bottleneck Problem with Wasserstein Distance

Jie Zhang, Virginia Tech, Blacksburg, VA, 24060, United States, jiezhang@vt.edu, Weijun Xie, Shabbir Ahmed

This paper considers data-driven distributionally robust combinatorial bottleneck problem (DR-CBP), where the cost vector is stochastic, and its probability distribution is from a family of distributions centered at the empirical distribution based on Wasserstein metric. We first show that CBP admits an equivalent dual form. Based on this result, we are able to derive a compact mixed integer linear programming (MILP) formulation for DR-CBP, which can be solved efficiently by the decomposition algorithm with binary search. Our numerical study demonstrates the effectiveness of the proposed method.

3 - Joint Stocking and Pricing Decisions for Distributionally Robust Inventory Problems with Decision-dependent Demands

Hamed Rahimian, Postdoctoral Fellow, Northwestern University, Evanston, IL, 60208, United States, hamed@northwestern.edu, Sanjay Mehrotra

We study a distributionally robust approach to multi-product inventory problems, where the joint probability distribution of the products demands is unknown and depends on the products prices. Our goal is to obtain the optimal joint stocking and pricing decisions for some classes of decision-dependent ambiguity sets. We reformulate these models as optimization problems with bilinear terms. We study convexification techniques for the bilinear terms and propose a solution algorithm to solve the models. We illustrate our results on stylized problems.

4 - Distributionally Robust Service Center Location Problem with Decision Dependent Utilities

Fengqiao Luo, IEMS Northwestern University, Evanston, IL, 60208, United States, fengqiaoluo2014@u.northwestern.edu, Sanjay Mehrotra

We investigate a service center location problem with stochastic demand and utility gain. This type of problem arises from public healthcare project of building basic medical service clinics in rural communities where residents need to visit the clinics to get medical services. The utility gain by a resident after receiving the medical service from a specific clinic may vary when the resident tries to compare the service quality, the waiting time, the traveling distance and some other features with other nearby clinics in the area. The problem is formulated to be a two-stage distributionally-robust stochastic mixed 0-1 second-order cone program to maximize the total utility gain.

■ TE37

CC- Room 606

Bayesian Machine Learning

Sponsored: Optimization/Optimization Under Uncertainty

Sponsored Session

Chair: Matthias Poloczek, Uber AI Labs & University of Arizona, San Francisco, CA, 85721, United States

1 - Active Machine Learning for Automating Scientific Discovery

Roman Garnett, Washington University in St. Louis, St. Louis, MO, United States

Analyzing data to determine properties of interest can be very expensive, requiring human intervention or costly experiments. In this case it is critical that we allocate limited resources effectively. In active machine learning, we consider how to collect the most-useful data to achieve our experimental goals. We will discuss a particular setting modeling scientific discovery: “active search,” where we seek to discover rare, valuable points from a large set of alternatives. We will discuss the surprising difficulty of this problem and introduce efficient, nonmyopic polices. We will also outline a vision for automating scientific discovery by incorporating automated model construction.

2 - Exploration via Sample-efficient Subgoal Design

Yijia Wang, University of Pittsburgh, Pittsburgh, PA, 15213, United States, yiw94@pitt.edu, Matthias Poloczek, Daniel Jiang

The problem of exploration in unknown environments continues to pose a challenge for reinforcement learning algorithms. In this paper, we consider a new problem domain where an agent faces an unknown task in the future, assumed to be drawn from an unknown distribution of Markov decision processes, that it must learn within a small number of samples. Prior to this, the agent has opportunities to ``practice” in related tasks from the same distribution. We propose a sample-efficient Bayesian approach for subgoal design to maximize the expected performance over a distribution of tasks, given a limited number of interactions with the environment.

3 - Non-myopic Bayesian Optimization as a Markov Decision Process

Eric Lee, Cornell University, Ithaca, NY, United States

We present Bayesian optimization (BO) as a Markov decision process (MDP), in which global optimization is equivalent to maximization of a reward over a finite horizon. In this MDP setting, myopic acquisition functions are greedy policies maximizing immediate reward, whereas non-myopic acquisition functions are long-horizon policies maximizing a combination of immediate and future reward(s). We discuss qualitative behavior of these non-myopic acquisition functions with a few examples. We then present experimental results demonstrating the benefits of non-myopic BO. Finally, we discuss when non-myopic BO is appropriate by examining trade-offs between model accuracy and performance.

4 - High Dimensional Bayesian Optimization via Subspace Embeddings

Matthias Poloczek, Uber AI Labs & University of Arizona, San Francisco, CA, 85721, United States, Amin Nayebi, Alexander Munteanu

We present a theoretically founded approach for high-dimensional Bayesian optimization based on low-dimensional subspace embeddings. The error in the GP is bounded tightly when going from the original high-dimensional search domain to the low-dimensional embedding. This implies that the optimization process in the embedding proceeds essentially as if it were run directly on an unknown active subspace of low dimensionality. The argument applies to a large class of algorithms and GP models, including non-stationary kernels. We demonstrate empirically that this subspace embedding achieves better results than the previous methods based on Gaussian matrix projections and structure-learning.

■ TE38

CC- Room 607

Learning Algorithms - Theory and Applications

Sponsored: Optimization/Optimization Under Uncertainty

Sponsored Session

Chair: Huanan Zhang, Penn State University, State College, PA, 16803, United States

1 - Fast Algorithms for Online Personalized Assortment Optimization in a Big Data Regime

Sentao Miao, University of Michigan-Ann Arbor, Ann Arbor, MI, 48104, United States, semiao@umich.edu

We consider an online personalized assortment optimization problem where customers arrive sequentially and make choices following a multinomial logit (MNL) model with unknown parameters. We develop an algorithm which uses an idea similar to UCB, while updating the estimated demand parameters using an online convex optimization method. By applying this parameter updating strategy, the computational complexity of the algorithm remains constant. Theoretical performance upper bounds for both low and high dimensional problems are derived, and numerical experiments demonstrate that our algorithms perform well compared with several benchmarks.

2 - Marrying Stochastic Gradient Descent with Bandits: Learning Algorithms for Inventory Systems with Fixed Costs

Hao Yuan, University of Michigan, Ann Arobor, MI, United States, haoyuan@umich.edu, Qi Luo, Cong Shi

We consider a periodic-review single-product inventory system with fixed cost under censored demand. We assume the firm does not know the demand distribution a priori. We develop a nonparametric learning algorithm termed the (, S) policy that combines the powers of stochastic gradient descent, bandit controls, and simulation-based methods in a seamless and non-trivial fashion. We prove that the cumulative regret is O(log(T)T1/2), which is provably tight up to a logarithmic factor.

3 - Learning in Structured MDPs with Convex Cost Functions: Improved Regret Bounds for Inventory Management

Randy Jia, Columbia University, New York, NY, 10027, United States, rqj2000@columbia.edu, Shipra Agrawal

We consider a stochastic inventory control problem under censored demands, lost sales, and positive lead times, and design a learning algorithm for this problem when the underlying demand distribution is unknown. The goal is to bound regret of the algorithm when compared to the best base-stock policy. Our main contribution is a learning algorithm with a regret bound of $O(L\sqrt{T})$, where L is the known lead time. Our results significantly improve the previously best known regret bounds for this problem where the dependence on L was exponential and many further assumptions on demand distribution were required.

4 - Self Guided Approximate Linear Programs

Selvaprabu Nadarajah, College of Business, University of Illinois at Chicago, UH 2406, Chicago, IL, 60607, United States, selvan@uic.edu, Parshan Pakiman, Negar Soheili, Qihang Lin

Approximate linear programs (ALPs) provide policies and bounds for Markov decision processes (MDPs) arising in challenging applications in operations management and other domains. Using ALP entails designing parametric MDP value function approximations, which poses a significant implementation hurdle. We develop an ALP scheme that side-steps this issue by leveraging sampling techniques from machine learning.

■ TE39

CC- Room 608

Transportation, Freight

Contributed Session

Chair: Ioannis Fragkos, Rotterdam School of Management, Burg. Oudlaan 50, Rotterdam, 3062 PA, Netherlands

1 - A Stochastic Model for Correlated Freight Parking Systems

Abhishek Abhishek, Kuehne Logistics University, Hamburg, Germany, abhishek.abhishek@the-klu.org, Jan C. Fransoo

We propose a stochastic model in the framework of queueing theory for a correlated parking system consisting of a delivery bay and a street parking. If freight vehicles find vacant parking spots at the delivery bay, they enter the bay parking and complete their deliveries. Otherwise, they immediately move to street parking in order to find vacant parking spots so that they can make their deliveries. We investigate the proportion of lost vehicles and prove some lower and upper bounds of the probability of lost vehicles in the parking system. We numerically show the impact of allocating more or less parking spots to dedicated delivery bays on the probability of lost vehicles, and on the bay utilization.

2 - Optimization of Variable Speed of Batch of Trucks in Supply Chain under Uncertain Demand

Jasashwi Mandal, Indian Institute of Technology Kharagpur, Kharagpur, India, Adrijit Goswami, Manoj Kumar Tiwari

In this study, the issue of varying speeds of a batch of vehicles in a truck shipping problem is explored considering fuel consumption and carbon emission for vehicles. The aim is to minimize the supply chain cost including the transportation, holding costs and back ordering costs where transportation cost consists of fuel cost, truck and driver costs considering carbon emission. The problem is divided into some sub problems leading to a set of differential equations of total chain cost and solving these differential equations the optimal dynamic speeds are obtained. Furthermore, a numerical case study related to truck transportation is given to realize the advantages of varying speed policy.

3 - Stochastic Truck Appointment Systems

Mohammad Torkjazi, PhD Candidate at University of South Carolina, University of South Carolina, Columbia, SC, United States, Nathan Huynh, Ali Asadabadi

Truck appointment systems are used at marine container terminals to mitigate port congestion. Past studies have not considered uncertainty in port operations. This study proposes a model to consider stochastic factors contributing in designing truck appointment systems.

4 - Integrated Scheduling for Port-centric Supply Chain Considering Seaborne Uncertainties and Dynamic Tidal Levels

Xinglu Xu, Dalian University of Technology, Dalian, China, Wenyuan Wang, Yun Peng, Yong Zhou, Ying Jiang

This paper proposes a practical integrated scheduling model for a typical port-centric supply chain with consideration of seaborne uncertainties. Such uncertainties include the ship's uncertain arrival time and uncertain departure time caused by varying draft requirements and tidal levels. A multilevel genetic algorithm with reduced feasible region is developed. The results show that integrated scheduling can significantly reduce the overall cost. If the origin port allows ships to increase loading volume by taking a tide, a drastic fluctuation in inventory will be observed, especially in the destination port.Resource bottleneck can also be identified and analysed from our results.

5 - Strategic Planning of Multimodal Transportation Networks

Ioannis Fragkos, Rotterdam School of Management, Rotterdam, Netherlands, fragkos@rsm.nl, Joris Wagenaar, Martin Faro

We study the efficient strategic planning of multimodal transportation networks. We look at the common situation of a 3PL that can lease train wagons on an annual basis and respond to demand fluctuations via ad-hoc spot train rentals. We formulate the problem as a two-stage stochastic mixed-integer program. We use structural properties of the formulation and a column generation-based procedure that greatly reduce the search space of optimal solutions. Computational results illustrate the efficiency of our approach.

■ TE40

CC- Room 609

Optimization, Continuous and Nonlinear Programming

Contributed Session

Chair: Michael Perregaard, FICO, FICO House, International Square, Starley Way, Birmingham, B37 7GN, United Kingdom

1 - The Value of Coordination in Ride-sharing Platforms

Arash Haddadan, PhD student, Carnegie Mellon University, Pittsburgh, PA, United States, ahaddada@andrew.cmu.edu

Ride-sharing is a two sided platform of riders and drivers. The objective for ride-sharing algorithms is to maximize a combination of the profit for the ride-sharing platform, drivers' utilization, and riders' satisfaction. The main problems in running an effective ride-sharing are (1) long term procedure of setting base prices and (2) short term control triggers to filter and modulate demand by setting surge prices. These optimization problems are often solved independently. In this project we seek to introduce optimization procedures that allow for more elaborate coordination between different levels of this (multi-period) optimization problem. We will use a simple yet practical model.

2 - Implementation of Interior Point Method for Nonlinear Optimization Problems with Arbitrary Precision Arithmetic

Koei Sakiyama, Kansai University, Osaka, Japan, k620042@kansai-u.ac.jp, Masashi Noguchi, Hiroshige Dan

The interior point method is one of the efficient methods for solving nonlinear optimization problems (NLPs). The interior point method basically works well, but it sometimes fails to solve some numerically ill-posed NLPs. On the other hand, arbitrary precision arithmetic has attracted attention for avoiding numerical errors. In this research, we implemented an optimization solver which can solve NLPs by using the interior point method with arbitrary precision arithmetic. Moreover, this solver uses the automatic differentiation software which are implemented by ourselves.

3 - Smooth Quasi-newton Methods for Nonsmooth Optimization

Jiayi Guo, Shanghai University of Finance and Economics, Shanghai, China, Adrian S. Lewis

Sporadic informal observations over several decades (and most recently in Lewis-Overton, 2013) suggest that quasi-Newton methods for smooth optimization can also work surprisingly well on nonsmooth functions. This talk explores this phenomenon from several perspectives. First, we compare experimentally the two most popular quasi-Newton updates, BFGS and SR1, in the nonsmooth setting. Secondly, we study how repeated BFGS updating at a single fixed point can serve as a separation oracle (for the subdifferential). Lastly, we show how Powell's original 1976 BFGS convergence proof for smooth convex functions in fact extends to some nonsmooth settings.

4 - Airline Fleet Assignment Problem: Extensions and Solution Methods

Fan Xiao, Tongji University, Shanghai, China, 892225786@qq.com

In this talk, we will introduce two extensions to the traditional airline fleet assignment problem (FAP). In the first extension, we consider the crew resource availability and balance in FAP. In the second extension, we model the demand-price relationship use a piece-wise linear function. We adopt the traditional time-space network model to handle these extensions. Several decomposition algorithms are proposed to solve these models efficiently. Our computational results show that the proposed solution methods can be used for mid and large scale airline companies.

5 - Understanding Adaptive Gradient Algorithms and Non-gradient Algorithms for Training Neural Nets

Anirbit Mukherjee, Research Assistant, Johns Hopkins University, Baltimore, MD, United States, amukhe14@jhu.edu, Amitabh Basu, Enayat Ullah, Soham Dey, Anup Rao

There is burgeoning experimental evidence that arbitrarily large neural nets can be trained with simple iterative algorithms. This remains a fundamental mystery in the field though over the last year progress has happened towards explaining this in certain unrealistic edge cases particularly for asymptotically large nets. In this talk I will present the progress that our group has made in two different aspects of this question. Firstly we will present our new convergence theorems about adaptive gradient algorithms like RMSProp and ADAM which are empirically known to be the best algorithms to train nets in general. Secondly we will present certain non-gradient algorithms (``Trons") which under appropriate conditions can provably train neural nets at speeds one would expect from stochastic gradient algorithms but these work for constant sized nets where hardly any gradient based algorithms have been proven to work.

6 - Recent Developments in the FICO Xpress Solver

Michael Perregaard, FICO, FICO House, International Square, Starley Way, Birmingham, B37 7GN, United Kingdom

We will present recent developments in the linear, mixed integer and non-linear programming solvers within the FICO Xpress Optimization Suite.

■ TE41

CC- Room 610

Power Flow Optimization and Control

Sponsored: Optimization/Network Optimization

Sponsored Session

Chair: Mostafa Sahraei-Ardakani, University of Utah, Salt Lake City, UT, 84112, United States

Co-Chair: Sang Yuanrui

1 - Effective Power Flow Control via Distributed FACTS Considering Future Uncertainties

Yuanrui Sang, The University of Texas at El Paso, El Paso, TX, United States

Distributed FACTS (D-FACTS) is a light-weight version of flexible AC transmission systems (FACTS), which has a low cost and can be redeployed conveniently. This study proposes a computationally efficient stochastic allocation model for D-FACTS and studies their economic benefits compared to that of conventional FACTS under a wide range of future uncertainties. The results show that, with the same level of investment, D-FACTS can more effectively reduce transmission congestion and enhance renewable energy integration than conventional FACTS, and can better accommodate future uncertainties.

2 - Derivation and Generation of Path-based Valid Inequalities for Transmission Expansion Planning and Optimal Transmission Switching

Kyle Skolfield, Arizona State University, Tempe, AZ, United States, jskolfie@asu.edu, Adolfo Raphael Escobedo

To meet power demand under a limited budget, it is necessary to determine a low-cost transmission expansion plan (TEP). One way to increase savings and operational flexibility in this design is to allow for network reconfigurations via optimal transmission switching (OTS). TEP and OTS decisions can be jointly modeled in a DCOPF-based large-scale MIP. We develop a solution methodology based on valid inequalities (VIs) that incorporate network insights from path-based bus angle-differences to tackle this intractable problem. The VIs are used in a branch-and-cut framework. We also design a data-driven scheme for selecting the more effective VIs and test it via benchmark instances.

3 - Optimal Power Flow Control Dispatch Using a Series Voltage Source Formulation

Tom R. Nudell, PhD, Smart Wires Inc, Union City, CA, United States, Tom.Nudell@smartwires.com

Power flow control (PFC) installed strategically and dispatched optimally could save US electricity consumers 10s of billions of dollars annually. Efficiently solving the optimal PFC dispatch problem is important and impactful. For certain problems, we focus on optimizing PFC deployments and ignore the famous unit commitment economic dispatch problems. Previously, many approaches to this problem modeled PFC devices as variable series reactance. We have reformulated the problem using a voltage source model of PFC deployments. This talk will introduce the motivation for and the results from using algorithm approaches based on the voltage-source formulation.

4 - Topology Control for Power System Reliability

Mojdeh Khorsand, Assistant Professor, Arizona State University, Tempe, AZ, United States, mojdeh.khorsand@asu.edu, Mostafa Sahraei-Ardakani

Power system operators acquire reserves in an attempt to guarantee reliability; yet, reserve deliverability is not guaranteed. Prior research has shown that the use of transmission switching, or topology control, may help improve reserve deliverability. In this paper, transmission switching is used as a corrective mechanism to help the system achieve N-1-1 reliability. The methodology can be employed at the day-ahead time stage to ensure the system has acquired sufficient supplemental reserves. The results demonstrate that not only can corrective transmission switching be beneficial after N-1 contingency, but it can also help obtain an N-1-1 reliable solution.

5 - Novel Hybrid Magnetic/Electronic Control Devices for Power Systems

Aleksandar Dimitrovski, University of Central Florida, FL, United States

The concept of magnetic amplifier – an electromagnetic device that used to be common in electronic applications – has seldom been used in power systems. Several years ago, an innovative low-cost magnetic amplifier-based power flow control device (MAPFC) has been proposed. The uniqueness of MAPFC in comparison with the current state-of-the-art, flexible ac transmission system devices (FACTS), is in complete separation of control and controlled circuits. MAPFC uses the saturation property of the ferromagnetic core shared by ac and dc windings. The common magnetic field is used as the medium to control the ac winding reactance inserted in series with the controlled transmission line. Large power flows in the line can be regulated by small power dc currents in the control winding. A multimillion-dollar project on MAPFC for transmission systems was funded by DOE's ARPA-e GENI program. A follow up work on MAPFC for distribution systems is currently being funded by DOE OE's TRAC program. Some results from both projects will be presented and plans for future developments will be discussed.

6 - Power Flow Control and Optimization in Active Distribution Networks

Panagiotis Andrianesis, Boston University, Brookline, MA, 02446, United States, panosa@bu.edu, Michael C. Caramanis, Pablo Ruiz

We will present a coordination and control framework for grid-connected Behind-the-Meter (BTM) Solar PV and Distributed Energy Resources (DERs), which optimizes their net benefits to overall system operating cost while increasing grid asset utilization. The framework integrates small scale BTM Solar PV with DERs, including energy storage, storage-like loads (notably Electric Vehicles), flexible loads, building controls, and smart appliances. It estimates spatiotemporal marginal costs of real and reactive power and uses them to optimize both the grid and the PV/DER operational profiles.

■ TE42

CC- Room 611

Network Optimization Algorithms and Applications

Sponsored: Optimization/Network Optimization

Sponsored Session

Chair: Oscar Guaje, Universidad de los Andes, 111021, Colombia

1 - A Hybrid Algorithm for Generating Multivariate Correlated Random Vectors

Oscar Guaje, Universidad de los Andes, Bogotá, 111021, Colombia, oo.guaje10@uniandes.edu.co, Andres L. Medaglia, Jorge A. Sefair

Existing methods to generate multivariate correlated random numbers rely on the properties of the input distributions. In this talk, we present a distribution-free algorithm to reorder independently generated samples to induce a target Pearson (and other) multivariate correlations. Our network-based algorithm combines an iterative local search with mathematical programming elements to both exploit the underlying problem structure and to diversify and intensify the search. Our results compare favorably against existing methods in terms of speed and solution quality.

2 - Mobility Problems with Predicted Uncertainties in Infrastructure Flow Capacities

Pitu Mirchandani, Arizona State University, Tempe, AZ, United States, Ketut Gita Ayu

Primary hurricane phenomena of concerns for disaster response operations are storm surge, torrential rain, and strong winds. These storm hazards can inflict significant amount of damage, particularly on the land transportation network, affecting population's ability to move during/after the storm event. We developed a cascading network failure model to accentuate this mobility issue. The model takes the scenario-level spatial-temporal storm impacts generated by the data-driven probabilistic scenarios model from our previous work, as input to predict uncertainties in network flow capacities in Florida during Hurricane Irma.

3 - Control of Stochastic Disease Network Games via Influential Individuals

Ceyhun Eksin, Texas A&M University, College Station, TX, United States, eksinc@tamu.edu

We consider control of a disease spreading on a network. The current state of the disease sets up a network game between healthy and sick individuals in contact. Both types can take preemptive measures according to an equilibrium of the game which stochastically determine the next disease state. Individuals learn an equilibrium action solution via a decentralized iterative learning process. Our goal is to induce behavior that minimizes risky interactions by identifying a small number of influential individuals during the iterative learning process. We numerically establish the efficacy of influential individuals in eradicating an outbreak in comparison to a centrality metric-based isolation.

4 - Optimizing Intercity Transportation Network Considering Passengers' Tour Behavior

Arata Suzuki, Narita International Airport Corporation, Chiba, Japan, Hiromichi Yamaguchi, Daisuke Fukuda

This study proposes a novel method of intercity transport network optimization incorporating tour-based (e.g. home or airport -> a primary destination -> a secondary destination -> home or airport) passenger behavior. The model is formulated as mixed integer-linear programming without enumerating enormous combinations of possible destinations and routes. Concepts of destination attractiveness and cross-cut constraints have been incorporated to describe tour-based travel. We apply the proposed method to the transport network in Japan with nine major cities and find that the optimal network can be significantly changed in terms of topology with the increase in tour-based passenger.

5 - Shortest Paths in Railyard Networks

Mina Aliakbari, Texas A&M University, College Station, TX, United States, Joseph Geunes

We consider the problem of moving a set of connected railcars from an initial location to a final location in a railyard network. This problem is routinely encountered in hub yards, where inbound trains are broken down and then used to build outbound trains. We provide an integer programming formulation and propose a customized shortest-path network that defines key states on the underlying railyard network, as well as allowable state transitions, implicitly accounting for all feasible paths in the railyard network. We discuss the advantages of each approach and present computational results.

■ TE43

CC- Room 612

Infrastructure Optimization

Sponsored: Computing

Sponsored Session

Chair: Robert Curry, United States Naval Academy, Annapolis, MD, United States

1 - A Hybrid Algorithm for Tri-level Optimization with Partial Protection and Interdiction

Nafiseh Ghorbani Renani, Graduate Research Assistant, University of Oklahoma, Norman, OK, United States, nafiseh.ghorbani@ou.edu, Kash Barker, Andres David Gonzalez

We explore the tradeoff between investments in vulnerability reduction and recoverability improvement in systems of interdependent networks by proposing a tri-level protection-interdiction-restoration model, depicted as a defender-attacker-defender model. We propose a hybrid solution technique to solve the tri-level optimization formulation by iteratively solving smaller nested bi-level problems. To demonstrate the application of the model and efficient solvability of the proposed solution method, we apply this resilience interdiction formulation to a system of water, gas, and power networks in Shelby County, Tennessee.

2 - Dynamic Network Flow Problems Having Temporary ARC Activation Costs

Robert Curry, United States Naval Academy, Annapolis, MD, United States, rcurry@usna.edu, Cole Smith

Time-dependent network applications may require dynamic flows to be transmitted according to a non-simultaneous schedule of path-flows. We thus study a dynamic network flow problem that considers the presence of set up costs required to begin transmitting flow on an arc. This problem can be modeled as a dynamic version of the minimum cost flow problem having arc activation costs (MCF-A). We employ a relaxation-based algorithm for obtaining upper and lower bounds for this problem that solves a series of smaller MIPs. We present computational results to demonstrate the efficacy of our approach and extend this technique to other dynamic network flow problem variations having complicating constraints.

3 - A Stochastic Optimization Model for Evaluating Preparedness and Restoration Strategies of Interdependent Networks

Jin-Zhu Yu, Vanderbilt University, Nashville, TN, United States, yujinzhu88@gmail.com, Hiba Baroud

Interdependent infrastructure systems are particularly vulnerable to disruptions when compared to a single infrastructure system. Effective preparedness and restoration plans are critical to the management of infrastructure systems. This study develops a two-stage stochastic optimization model that integrates preparedness and restoration strategies to (i) reduce the expected total cost of disaster planning (e.g., network hardening scheme) and recovery activities (e.g., the number of repair crews required and their schedule) and (ii) enhance the time-dependent resilience of interdependent infrastructure systems post-disruption.

■ TE44

CC- Room 613

Joint Session ICS/DM/Practice Curated: Optimization in Machine Learning III

Sponsored: Computing

Sponsored Session

Chair: John W Chinneck, Carleton University, Ottawa, ON, K1S 5B6, Canada

1 - Learning Optimal Combination of Forecasts using Best Subset Selection

Brad J. Johnson, PhD Candidate, Carnegie Mellon University, Pittsburgh, PA, 15213, United States, bradj@andrew.cmu.edu, Nick V. Sahinidis

For decades, using a combination of forecasts has been shown to improve forecasting accuracy and robustness; however, there has been continued debate over the selection and weighting of individual methods. This work proposes the use a mixed integer formulation of the best subset selection problem to simultaneously select forecast methods and their weights by minimizing the Bayesian Information Criterion. The proposed algorithm is then applied to the 100k time series used in the M4 Forecasting Competition to learn novel combinations.

2 - Imbalanced Learning with Linear Programming Support Vector Machine with Application in Weather Data

Elaheh Jafarigol, University of Oklahoma, Norman, OK, 73071, United States, elaheh.jafarigol@ou.edu, Theodore B. Trafalis

Learning from imbalanced data sets is one of the aspects of predictive modeling and machine learning that has taken a lot of attention in the last decade. The model proposed in this presentation is a Linear Programming Support Vector Machine with applications in weather data, collected from the Bureau of Meteorology system in Australia. The proposed approach has yielded a significant improvement in predicting the minority class and decreased the model's bias towards the majority class as it is seen in most machine learning algorithms.

3 - Scale Invariant Power Iteration

Cheolmin Kim, Northwestern University, Evanston, IL, 60201, United States, cheolminkim2019@u.northwestern.edu, Diego Klabjan, Youngseok Kim

Several machine learning models can be formulated as maximization of a scale invariant function under a Euclidian ball constraint, for example, PCA, GMM, NMF. We generalize power iteration to this setting and analyze convergence properties of the algorithm. Our main result states that if initialized close to a local maximum, then the algorithm converge to this local maximum. Also, the convergence rate is linear and thus equal to the rate of power iteration. Numerically, we benchmark the algorithm against state-of-the-art methods to find out that the algorithm outperforms benchmark algorithms.

4 - The Optimization Methods in SAS Deep Learning Software

Yan Xu, SAS Institute Inc., Cary, NC, United States, Yan.Xu@sas.com

Deep learning is a popular type machine learning that trains computers to perform human-like tasks, such as recognizing speech, identifying image objects or making predictions. Optimization is the core component of deep learning systems. In this talk, we present the implementation details and computational results of the optimization methods that power SAS deep learning toolkit.

■ TE45

CC- Room 614

Methods for Large Scale, Nonlinear and Stochastic Optimization – III

Sponsored: Optimization/Nonlinear Programming

Sponsored Session

Chair: Albert Solomon Berahas, Bethlehem, PA, 18018, United States

Co-Chair: Alejandra Pena Ordieres, Northwestern University, Evanston, IL, 60208, United States

1 -Linear Interpolation vs. Gaussian Smoothing in Derivative-free Optimization

Katya Scheinberg, Cornell University, Ithaca, NY, 18015, United States, Albert Solomon Berahas, Liyuan Cao

We consider derivative free optimization problems, where the objective function is smooth but is computed with some amount of noise. We are motivated by policy optimization in reinforcement learning. We provide a convergence rate analysis for a first-order line search method, and derive the conditions on the gradient approximations that ensure this convergence. We then demonstrate via rigorous analysis of the variance and by numerical comparisons on reinforcement learning tasks that the Gaussian sampling method for gradient approximation is significantly inferior to the orthogonal sampling as well as more general interpolation methods.

2 - Solving Chance-constrained Problems via a Smooth Sample-based Nonlinear Approximation

Alejandra Pena-Ordieres, Northwestern University, Evanston, IL, 60208, United States, James Luedtke, Andreas Waechter

In this talk, we introduce a method for solving nonlinear continuous optimization problems with chance constraints. The method reformulates the probabilistic constraint as a quantile function and approximates the quantile using a differentiable sample average approximation. This formulation can be directly used by standard nonlinear optimization solvers in the case of single chance constraints. Furthermore, we propose an Sl1QP-type trust-region method to solve instances with joint chance constraints. We illustrate empirically that the method scales well with the sample size and that the smoothing can be used to counteract the bias in the approximation induced by sampling.

3 - Reduced Space Optimization for Problems with Group Sparsity

Daniel Robinson, Associate Professor, Lehigh University, Bethlehem, PA, 21218, United States

I discuss an optimization framework for solving problems with sparsity inducing regularization. Such regularizers include Lasso (L1), group Lasso, and latent group Lasso. The framework computes iterates by optimizing over small dimensional subspaces, thus keeping the cost per iteration relatively low. Theoretical convergence results and numerical tests on various learning problems will be presented.

4 - Stochastic Linear Bilevel Programs: Overcoming Degeneracy in the Lower Level Problem.

Francisco I. Jara-Moroni, Universidad de Santiago, Av. Santiago, Chile, francisco.jara.m@usach.cl, Andreas Waechter

This is a numerical study for Stochastic Linear Bilevel problems. We solve a sampled version by means of a global/local search together with an alternating weights technique which steers towards better solutions, by overcoming degeneracy of the lower level problem. We are able to find the global solution of the true problem in small instances, while in larger ones the local solutions obtained overtake those found from globally solving smaller subsamples. Computation time is drastically reduced, as compared to the best performing subsampled global solution. We show that our technique manages to find good approximations of global solutions, even if the subsample is not solved to globally solved.

■ TE46

CC- Room 615

Game Theory and Control Mechanisms in Transportation Operations

Sponsored: Transportation Science & Logistics/Intelligent Transportation Systems (ITS)

Sponsored Session

Chair: Xiaotong Sun, University of Michigan, Department of Civil and Environmental Enginee, Ann Arbor, MI, 48109, United States

1 - Decentralized Game-theoretical Approaches for Behaviorally-stable and Efficient Truck Platooning

Xiaotong Sun, University of Michigan, Ann Arbor, MI, United States, Yafeng Yin

Vehicle platooning enabled by the connected automated vehicle (CAV) technology has been identified to bring energy savings and labor-saving. However, vehicles from different owners may not willing to platoon together since benefits vary over different positions in a platoon. This study investigates a decentralized multi-agent system where individual-rational agents form platoons under designated mechanisms which also decide the benefit reallocation simultaneously. Specifically, mechanisms based on auction, bargaining game and stable matching are introduced for different scenarios. By leveraging CAV technology, such a system is flexible, scalable and real-time implementable.

2 - Do Self-driving Cars Swallow Public Transport? A Game-theoretical Perspective on Transportation Systems

Maximilian Schiffer, Technical University of Munich, Munich, Germany, schiffer@tum.de, Stanford University, Stanford, CA, United States, schiffer@tum.de, Nicolas Lanzetti, Gioele Zardini, Michael Ostrovsky, Marco Pavone

The advent of autonomous mobility-on-demand (AMoD) systems constitutes a paradigm shift for future transportation systems. While many experts envision huge benefits from AMoD systems, others warn against negative externalities, e.g., cannibalization of public transport. To this end, we develop a game-theoretical framework that captures the dynamics between mobility service providers and non-cooperative customers. We study the corresponding game equilibrium and assess the impact of an AMoD system competing with public transport in a transportation system where customers select their trips in a multimodal fashion. We present results for a real-world case study for the city of Berlin.

3 - Traffic and Vehicle Assignment of Shared Autonomous Vehicles: A Nash-Cournot Game Formulation

Emmanouil Chaniotakis, Technical University of Munich, Munich, Germany, m.chaniotakis@tum.de, Santhana Krishnan Narayanan, Constantinos Antoniou

Road users select paths and departure time to minimize their disutility forming a Dynamic User Equilibrium (DVI - fixed point problem); SAV Service Operator try to maximize their performance forming appropriate SAV chains (combinatorial problem). The final objective of this formulation a traffic assignment and SAV chain formation, such that both road users and SAV service operator obtain their optimal solutions simultaneously, forming a Nash-Cournot equilibrium, where no player is better o by unilaterally changing decisions. An iterative is proposed with convergence criteria based on change in path flow from DUE and change in total system cost from SAV operations.

4 - A Coordinated Route-guidance System for Connected Vehicles under Mixed-strategy Congestion Game with Information Perturbation

Stephen Spana, University of Florida, Gainesville, FL, United States, sspana@ufl.edu, Lili Du, Yafeng Yin

This project develops a coordinated routing scheme for connected vehicles, where the mixed-strategy route choice for drivers is based on strategically perturbed traffic information. Analytically we show that for small perturbation amounts, significant system improvement is achieved with a relatively low corresponding user optimality loss. Through simulation we verify our analytic results, and explore the impacts of information perturbation on various performance measures (e.g. travel time) for different congestion levels using the Sioux Falls network.

5 - VCG-inspired Value-of-time Auctions for Road Intersection Priority

Carlin Liao, University of Texas, Austin, TX, United States, Stephen Boyles

Intersection auctions with automated vehicles increase social welfare by accounting for drivers' relative priority levels. Prior research has developed a preliminary mechanism, but use of second-price payments and fixed-value bids disincentive truthful behavior. This study proposes bidding values of time (instead of fixed valuations) and a payment mechanism derived from Vickrey-Clark-Groves, charging drivers in the auction-winning lane the cost they impose on others: the value of the time the winning movement prevents the second highest bidding movement from taking action.

■ TE47

CC- Room 616

TSL Best Paper Award

Sponsored: Transportation Science & Logistics

Sponsored Session

Chair: Carolina Osorio, Massachusetts Institute of Technology, Cambridge, MA, 02139, United States

1 - Exact Solution of the Evasive Flow Capturing Problem

Okan Arslan, HEC Montreal, Montreal, QC, Canada, Ola Jabali, Gilbert Laporte

Please check the mobile app for this abstract.

2 - Service Region Design for Urban Electric Vehicle Sharing Systems

Long He, National University of Singapore, Mochtar Riady Building, BIZ1 8-73, 15 Kent Ridge Drive, Singapore, 119245, Singapore, Ho-Yin Mak, Ying Rong, Z. Max Shen, Z. Max Shen

Please check the mobile app for this abstract.

■ TE48

CC- Room 617

Joint session TSL/OPT.Under Uncertainty: ADP/Reinforcement Learning in Vehicle Routing I

Sponsored: Transportation Science & Logistics/Freight Transportation & Logistics

Sponsored Session

Chair: Maciek A Nowak, Loyola University Chicago, Chicago, IL, 60611, United States

1 - Anticipatory Synchromodal Transportation Planning

Martijn Mes, University of Twente, Building Ravelijn, PO Box 217, Enschede, 7500 AE, Netherlands, m.r.k.mes@utwente.nl

We present the problem of selecting transport modes and transfers in a synchromodal network over a multi-period horizon, with freights becoming known gradually over time. We model this problem as a Markov Decision Process (MDP) and combine Approximate Dynamic Programming (ADP) and the Value of Perfect Information (VPI) to solve it. We show that VPI drastically reduces the number of ADP iterations and that our look-ahead approach has significant benefits compared to benchmark heuristics. We also present a serious game, called Trucks and Barges, illustrating the described problem and solution methods.

2 - Multi-period Workload Balance in Last-mile Urban Delivery

Yang Wang, Tsinghua University, Tsinghua University, Beijing, 100084, China, yang-wan15@mails.tsinghua.edu.cn, Lei Zhao, Martin W. P. Savelsbergh

In urban delivery, the last-mile station manager needs to consider workload balance among couriers when dispatching delivery orders. While couriers expect to deliver more packages to increase their piecework-based incomes, they favor the assignments that demand less effort (travel distance, time, etc.). We model the workload balance problem over a finite planning horizon as a stochastic dynamic program and study the impact of various dispatching policies that differentiate these two types of workload balance.

3 - Control of Autonomous Electric Fleets for Ridehail Systems

Nicholas D. Kullman, University of Tours, Tours, 98119, France, nicholas.kullman@etu.univ-tours.fr, Jorge E. Mendoza, Justin Goodson, Martin Cousineau

We consider a ridehail company operating a fleet of autonomous electric taxis that serve requests arising randomly throughout a region. The operator is responsible for assigning taxis to requests, as well as repositioning and recharging the taxis in anticipation of future requests. We model the problem as a Markov decision process. We compare solution methods from classical approximate dynamic programming — heuristic policies and lookaheads — with those of deep reinforcement learning — deep Q networks. We also provide a dual bound to gauge the effectiveness of these approaches by calculating the expected value with perfect information.

4 - Customer-driver Familiarity in Service Routing

Maciek A. Nowak, Loyola University Chicago, Information Systems and Supply Chain Mgmt, Quinlan School of Business, Chicago, IL, 60611, United States, mnowak4@luc.edu, Marlin Wolf Ulmer, Dirk C. Mattfeld, Bogumil Kaminski

We develop and solve a tactical model to specify the long-term implications of improved customer-driver familiarity, introducing a solution methodology for the stochastic and dynamic multi-period routing problem with customer-driver familiarity. Our methodology utilizes a policy that explicitly invests in the familiarity between selected customer-driver pairs, encouraging the development of relationships that are tactically beneficial. We show that this investment policy leads to a reduction in cost compared to a myopic policy focused on routing and service costs in the short term, while increasing the overall level of familiarity between customers and drivers.

■ TE49

CC- Room 618

Joint Session TSL/Urb/Practice Curated: Smart City Operations with Data Analytics

Sponsored: Transportation Science & Logistics/Urban Transportation Sponsored Session

Chair: Sheng Liu, University of California, Berkeley, Berkeley, CA, 94709, United States

Co-Chair: Alexandre Jacquillat, Carnegie Mellon University, Pittsburgh, PA, 15213, United States

1 - Urban Bike Lane Planning with Bike Trajectories

Sheng Liu, University of California, Berkeley, Berkeley, CA, 94709, United States, lius10@berkeley.edu, Xiang Ji, Zuo-Jun Max Shen

In this paper, we develop a novel bike lane planning model based on the bike trajectory data. We formulate the bike lane planning problem as an integer program to maximize the coverage of cyclists as well as the continuity of bike lanes. Based on the structural properties of the model, we develop a Lagrangian relaxation method as well as a mixed integer linear programming (MILP) method. The Lagrangian relaxation dual is proved to be solved in polynomial time for a special class of utility functions. We apply the model to the Zhuhai city of China using a large-scale trajectory data set collected from a dock-less bike sharing company.

2 - Optimal Transit Planning: Interactions with Ridehailing, Congestion and Passenger Choice

Vikrant Vaze, Dartmouth College, Murdough Center, Hanover, NH, 03755, United States, vikrant.s.vaze@dartmouth.edu, Keji Wei, Alexandre Jacquillat

Ride-hailing services introduce additional vehicles on the road, contribute to urban traffic congestion, and are sometimes responsible for falling public transit ridership. On the other hand, a high quality public transit system is an effective means to alleviate urban road traffic congestion. This interdependence motivates the following question: can public transit and ride-hailing co-exist and thrive to improve the overall social welfare? We develop a new mixed-integer linear optimization model, and a new set of algorithms, to optimize transit networks while explicitly accounting for the road congestion and passengers' mode-switching behavior between transit and ride-hailing services.

3 - Robust Repositioning for Vehicle Sharing

Zhenyu Hu, National University of Singapore, Singapore, 119245, Singapore, Long He, Meilin Zhang

Our paper discusses the operational decision of dynamic fleet repositioning for vehicle sharing. We first formulate the problem as a stochastic dynamic program to minimize the expected total repositioning cost and lost sales penalty. To solve for a multi-region system, we deploy the distributionally robust approach that can incorporate demand temporal dependence, motivated by observations from real trip data. In a real-world case study, we quantify the "value of repositioning" and compare with several benchmarks to demonstrate that the proposed solutions are computationally scalable and in general result in lower cost with less frequent repositioning.

4 - An Equilibrium Analysis of the Parking Problem with Autonomous Vehicles

Neda Mirzaeian, PhD Candidate, Carnegie Mellon University, Pittsburgh, PA, 15217, United States, mneda@andrew.cmu.edu, Soo-Haeng Cho, Zhen Qian

We investigate a potential of autonomous vehicles (AVs) to solve the problem commuters face when traveling to a city center for work. We characterize the user equilibrium for commuters by developing a continuous-time traffic model that takes into account parking fees and traffic congestion as the main economic deterrent to driving. In this model, commuters decide their departure time as well as their parking location among central, peripheral, and external facilities. We show that, due to congestion, the expensive central facility can still be a viable option, even though AVs have the ability to travel to the cheap external facility.

5 - Customer Preference and Station Network in the London Bike Share System

Pu He, Columbia University, Uris Hall, Cub 4H, New York, NY, 10027, United States, Fanyin Zheng, Elena Belavina, Karan Girotra

We study customer preference for the bike share system in the city of London. We estimate a structural demand model on the station network to learn the preference parameters and use the estimated model to provide insights on the design and expansion of the bike share system. We highlight the importance of network effects in the system. We find that, in London city, allocating resources to some areas of the station network can be 10 times more beneficial than others in terms of system usage, and that the currently implemented station density rule is far from optimal. We develop a new method to deal with the endogeneity problem of the choice set in estimating demand for network products.

■ TE50

CC- Room 619

Transportation, Public II

Contributed Session

Chair: Rahul Deshmukh, Pacific Northwest National Laboratory, Richland, WA, 99354, United States

1 - The Impact of Perceived Corporate Social Responsibility on Employee Engagement: The Case of Qatar

Fatma H. Al Amri, Ministry of Energy & Industry, Doha, Qatar, Amit Das, Omar Ben-Ayed

This work investigates the role of preceived corporate social responsibility (CSR) in enhancing employee engagement (EE) in the State of Qatar. The scope of CSR included activities targeted at employees, customers, the government, and society at large. We measured EE by organizational engagement and job engagement. We examined how these dimensions of EE are associated with employees' perception of the firm's CSR activities, controlling for the type of firm and the type of employee. Our results reveal that CSR to society and CSR to employees affect organizational engagement, whereas CSR to customers affects job engagement. CSR to the government is not significantly related to either aspect of EE.

2 - Trajectory Planning for Autonomous underwater Vehicles Using Mixed Integer Nonlinear Programming

Ricardo M. Lima, Research Scientist, King Abdullah University of Science and Technology, Thuwal, Saudi Arabia, ricardo.lima@kaust.edu.sa, Tong Wang, Loïc Giraldi, Omar Knio

This talk presents a detailed mixed integer nonlinear programming (MINLP) model for the time-optimal trajectory planning for autonomous underwater vehicles. The model takes into account vehicle kinematic constraints, obstacle avoidance, and a nonlinear flow field to represent the ocean current. A novel solution approach is proposed, involving an initialization strategy using multiple waypoints, MILP and MINLP approximated models, and a parallel computing approach. The performance of the various models and methodology is discussed. Insights regarding trajectory planning are presented.

3 - Do Low Emissions Zones Reduce Air Pollution in Cities?

Virginie Lurkin, Assistant Professor, Eindhoven University of Technology, Eindhoven, Netherlands, v.j.c.lurkin@tue.nl

The urbanization trend gave rise to increased traffic flows in areas with dense population, creating more traffic congestion and air pollution. In order to tackle this problem, many cities around the world have chosen to introduce Low Emission Zones (LEZ). LEZ are geographical areas in which the operations of more polluting vehicles are restricted. Few quantitative studies have been published on the effectiveness of these policy interventions. In this paper, we show that Low Emission Zones (LEZ), as currently defined by most cities, can only constitute a quick win to decrease CO2 emissions within the restricted area, but are not sustainable stand-alone solutions to globally reduce air pollution.

4 - Injury Severity Analysis of Motorcycle Crashes in Florida Work Zones with Mixed Logit Approach

Rahul Deshmukh, University of South Florida, Tampa, FL, United States, deshmukh@mail.usf.edu

Injury Severity Analysis for Motorcycle Crashes In Work Zones In Florida with Mixed Logit Approach Work zone related crashes are increasing in Florida since 2014. There were 8,494 crashes in work zone in 2017 relative to 5,409 crashes in 2014. This equates to one work zone crash in almost every hour in 2017 as opposed to one crash in every 1.6 hour. As such, work zone safety is considered one of the important emphasis areas in Florida Strategic Highway Safety Plan (SHSP).

■ TE51

CC- Room 620

Joint Session AAS/TSL Air/Practice Curated: Crew and Flight Planning Practice

Sponsored: Aviation Applications

Sponsored Session

Chair: Fredrik Altenstedt

1 - Alternative Pricing in Column Generation for Airline Crew Rostering

Emily Curry, Jeppesen, Gothenburg, Sweden, Emily.Curry@jeppesen.com

In column generation for airline crew rostering, rosters with the potential of improving the current solution are generated by solving the pricing problem. The generated rosters must satisfy all rules that are applied at the airline. Since these vary between different carriers, the pricing problem can be treated as a black-box optimization problem, where rules and costs are considered unknown. We suggest three alternative methods for solving the black-box pricing problem. The first method uses binary particle swarm optimization to search for rosters. The other two methods use surrogate modeling to fit a nonlinear surrogate function that captures the unknown cost and legality functions.

2 - Why More Aircraft Performance Data Means a More Powerful Flight Plan Optimisation

Jacques Wild, Jeppesen, Gothenburg, Sweden, jacques.wild@jeppesen.com

An important aspect of flight planning optimization is being able to compare cost of aircraft operation at any feasible state, i.e. at all altitudes, weights, and weather conditions. However, not all aircraft have enough data to evaluate each flight state, either because of the lack of the flight test data or not appreciating the benefits of providing high resolution data to flight planning. In this presentation, we demonstrate the benefits of using high resolution aircraft performance data.

3 - Teaming in Airline Crew Schedule Optimization

Fredrik Altenstedt, Jeppesen, Odinsgatan 9, Göteborg, SE-411 03, Sweden

Operational stability of a crew schedule is improved by keeping crew together as much as possible. The cost of the plan can however often be lowered by splitting the crew. The benefit of splitting is driven by base imbalances, different costs for different crew categories as well as varying staffing need for different flights. In the case of teaming between cabin and cockpit splitting is also driven by different work time rules In this presentation we will address how teaming is specified and enforced in the Jeppesen Crew Pairing optimizer, as well as discuss the benefit to some of our clients.

4 - Optimizing the Pilot Manpower Problem under Career Bid Uncertainty

Pontus Ekh, Jeppesen Systems AB, Gothenburg, 41512, Sweden, pontus.ekh@jeppesen.com

The pilot manpower problem focus on creating a resource plan for airlines. A key decision is assigning qualification training. Airline regulations based on pilots' seniorities and preferences impose restrictions on who can be assigned training. The problem can be formulated as a MIP if the pilots' preferences are known a priori. However some airlines postulate that a vacancy posting must be done before collecting preferences. Pilots are then awarded training according to a fixed process. Creating a good posting is essential for these airlines. We propose a solution approach combining the previous MIP model and simulating several bid outcomes and awards.

■ TE52

CC- Skagit 1

Dynamic Learning in Revenue Management and Market Analytics

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Rene A. Caldentey, The University of Chicago, Chicago, IL, 60637, United States

Co-Chair: Yifan Feng, The University of Chicago Booth School of Business, Chicago, IL, 60637, United States

1 - Simple Bayesian Algorithms for Best-arm Identification

Daniel Russo, Columbia University, New York, NY, United States

This talk considers the optimal adaptive allocation of measurement effort for confidently identifying the best among a finite set of options or designs. I propose top-two sampling, a template for designing algorithms that adaptively allocate measurement effort. Four simple Bayesian algorithms designed via this template are shown to have strong performance in numerical experiments, and a unified analysis establishes each satisfies strong asymptotic optimality properties.

2 - Inferring Consideration Sets from Sales Transaction Data

Dmitry Mitrofanov, New York University, New York, NY, 10012, United States, Srikanth Jagabathula, Gustavo J. Vulcano

In this paper, we study a methodology to identify competition sets from sales transactions in a data-driven way. First, we address the problem of identifiability of consider-then-choose models from the data. Then, we suggest the framework to estimate these models and infer competition sets. We apply the proposed methodology to the data obtained from a car-sharing platform and analyze the real-world settings where accounting for consideration sets can boost the predictive performance of the choice models. Our findings show that consider-then-choose models tend to be robust to the noise in the data and their relative importance in prediction tasks increases with the growing noise factor in the data.

3 - Learning Customer Preferences from Personalized Assortments

Yifan Feng, University of Chicago, Chicago, IL, 60637, United States, yifan.feng@chicagobooth.edu, Rene A. Caldentey, Christopher Ryan

A company wishes to commercialize the best version of a product out of a menu of available alternatives. The company does not know customers' preferences over the set of alternatives and relies on a voting system that allows potential buyers to vote for their preferred version. Under a general ranking-based choice model framework, we study how to dynamically customize each individual voter's choice set, so as to identify the top-ranked alternative with a fixed probabilistic confidence level, while using a minimal number of votes.

4 - Online Matching with Stochastic Rewards: Optimal Competitive Ratio via Path Based Formulation

Rajan Harish Udwani, Columbia University, 639W 204th St, 6D, New York, NY, 10034, United States, Vineet Goyal

Online matching with stochastic rewards is a generalization of the online bipartite matching problem, with applications in resource allocation, internet advertising, crowdsourcing, and other domains. Various algorithms have been proposed for special cases of this problem, yet finding one with the optimal competitive ratio has proven hard. We show that natural generalizations of classical algorithms achieve (near) optimal competitive ratios for this problem in various cases of interest. Our analysis relies on finding a tight bound on the clairvoyant via a novel path based formulation, a technique we believe could be useful more broadly in other online-stochastic settings.

■ TE53

CC- Skagit 2

Machine Learning in Pricing

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Georgia Perakis, Massachusetts Institute of Technology, Cambridge, MA, 02142-1347, United States

Co-Chair: Lennart Baardman, University of Michigan, Ann Arbor, MI, 48109, United States

1 - Pricing for Heterogeneous Products: Analytics for Ticket Reselling

Max Biggs, University of Virginia, Charlottesville, VA, 02139, United States, maxbiggs@mit.edu, Rim Hariss, Michael Li, Georgia Perakis, Charles Hermann

We develop a framework for estimating heterogeneous price sensitivity in applications such as ticket reselling. We introduce a orthogonalized machine learning approach for a classification setting with confounding. The loss function we derive can be easily incorporated into off-the-shelf machine learning algorithms, including gradient boosted trees and neural networks. Using a wide range of synthetic data sets, we show this approach beats state-of-the-art machine learning approaches for estimating price sensitivity and prove analytical properties for this estimator.

2 - Joint Pricing and Production: An Analytics Perspective

Qinshen Tang, National University of Singapore, Singapore, 117592, Singapore, tang@u.nus.edu, Georgia Perakis, Melvyn Sim, Peng Xiong

We integrate K-means clustering with robust optimization to address a two-period joint pricing and production problem. We construct a K-means ambiguity set and propose an affine recourse approximation to reformulate it as a MILP. Our framework can increase expected profits by 1.11% on average when applied to most out-of-sample tests.

3 - Joint Prediction and Optimization in Pricing

Lennart Baardman, University of Michigan, Operations Research Center, Ann Arbor, MI, 02139-4307, United States, baardman@umich.edu, Tamar Cohen-Hillel, Georgia Perakis

Most applications of analytics involve solving optimization models that include uncertain parameters. Models from statistics and machine learning are estimated and substituted for these uncertain parameters, after which the problem can be optimized. Instead of this two stage approach, we propose a single optimization model that jointly predicts and optimizes. We consider an application in pricing for a large paper product manufacturer while accounting for uncertain reorder quantities and timing by their retail clients. On real-world data, we show a significant improvement by using our one stage method.

4 - Dynamic Learning with Frequent New Product Launches

Junyu Cao, Berkeley IEOR, Berkeley, CA, 94706, United States, Wei Sun

Motivated by the phenomenon that companies introduce new products to keep abreast with customers' rapidly changing tastes, we consider a novel online learning setting where a profit-maximizing seller needs to learn customers' preferences through offering recommendations, which may contain existing products and new products that are launched in the middle of a selling period. We propose a sequential multinomial logit (SMNL) model to characterize customers' behavior when product recommendations are presented in tiers. For the online problem, we propose a learning algorithm that simultaneously explores and exploits, and quantify its regret bound.

■ TE54

CC- Skagit 3

Online Optimizations in Revenue Management and Market Design

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Rad Niazadeh, Stanford University, Stanford, CA, 94305, United States

1 - LP-Based Pricing for Bayesian Online Selection

Amin Saberi, Stanford University, Palo Alto, CA, 94105, United States, saberi@stanford.edu, Nima Anari, Rad Niazadeh, Ali Shameli

In the Bayesian online selection problem, the goal is to design a pricing scheme for a sequence of arriving buyers that maximizes the expected social-welfare (or revenue) subject to different types of structural constraints. I will present a Polynomial-Time Approximation Scheme (PTAS) for special cases of this problem. The approach is based on rounding the solution of a hierarchy of linear programming relaxations that approximate the optimum online solution with any degree of accuracy plus a concentration argument that shows the rounding incurs a small loss.

2 - Constant-regret Policies for Online Resource Allocation

Siddhartha Banerjee, Cornell University, Ithaca, NY, 14853, United States, sbanerjee@cornell.edu

I will present online control policies with the first constant regret guarantees (i.e., additive optimality-loss that is constant in the horizon and resource budgets) for a wide variety of problems, including online resource-allocation, dynamic pricing with discrete price levels, online budgeted probing, and contextual bandits. All our policies are built out of a meta-algorithm, where we first construct a tractable offline benchmark that satisfies a notion we refer to as the Bellman inequalities, and then use this benchmark with re-solving to construct a feasible online policy.

3 - Online Resource Allocation under Partially Predictable Demand

Vahideh Manshadi, Yale University, New Haven, CT, 06511, United States, vahideh.manshadi@yale.edu, Patrick Jaillet, Dawsen Hwang

For online resource allocation problems, we propose a new demand arrival model where the sequence of arrivals contains both an adversarial component and a stochastic one. Our model requires no demand forecasting; however, due to the presence of the stochastic component, we can partially predict future demand as the sequence of arrivals unfolds. Under the proposed model, we study the problem of the online allocation of a single resource to two types of customers, and design online algorithms that outperform existing ones. We also study the classical secretary problem under our proposed arrival model, and we show that randomizing over multiple stopping rules may increase the probability of success.

4 - Autobidding Algorithms

Ashwinkumar Badanidiyuru, Research Scientist, Google Research, Mountain View, CA, United States

Autobidding is becoming increasingly important in the domain of online advertising, and has become a critical tool used by many advertisers for optimizing their ad campaigns. These tools offer to optimize advertiser goals (post click purchases/total clicks) subject to various constraints (ROI/budget). In this work we formulate and study several allocation and learning related problems in the area of automated bidding.

5 - Pandora's Problem with Nonobligatory Inspection

Hedyeh Beyhaghi, Cornell University, Ithaca, NY, 14853, United States, Robert Kleinberg

Weitzman's Pandora's problem furnishes the mathematical basis for optimal search theory in economics. Nearly 40 years later, Doval introduced a version of the problem in which the searcher is not obligated to pay the cost of inspecting an alternative's value before selecting it. In this work we provide the first non-trivial approximation guarantees for this problem. We introduce a family of "committing policies" such that it is computationally easy to find and implement the optimal committing policy. We prove that the optimal committing policy is guaranteed to approximate the fully optimal policy within a $1-1/e=0.63...$ factor.

6 - Adaptive Submodular Ranking and Routing

Fatemeh Navidi, University of Michigan, Ann Arbor, MI, 48105, United States, Prabhanjan Kambadur, Viswanath Nagarajan

We study a general stochastic ranking problem where an algorithm needs to adaptively select a sequence of elements to cover a random scenario at minimum expected cost, where the coverage is captured by some submodular function. We obtain a logarithmic factor approximation algorithm for this problem, which is the best possible. We also extend our results to an adaptive routing problem, where costs are determined by a metric. Our approximation ratio nearly matches the best bound known for some special cases. Finally, we present experimental results for some applications of adaptive ranking.

■ TE55

CC- Skagit 4

Revenue Management with Social and Digital Technologies

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Joline Uichanco, University of Michigan, Ross School of Business, Ann Arbor, MI, 48109-1234, United States

1 - Dynamic Optimization in Display Advertising

Elaheh Fata, Massachusetts Institute of Technology, Aeronautics and Astronautics, Cambridge, MA, 02139, United States, efata@mit.edu, Lennart Baardman, Abhishek Pani, Georgia Perakis

The large growth of online advertising and the associated growth in personalized data allows advertisers to customize their advertisements for specific customers. The level of customization varies between different types of advertising. The ability of showing the right creative look of the ad to the customer is valuable, as it increases the chance of the customer interacting. Focusing on product display advertising, we are interested in dynamically customizing the product that is shown, but also potentially the creative look of the display itself.

2 - Pricing Fast-moving Products

Mengzhenyu Zhang, University of Michigan, Ann Arbor, MI, 48105, United States, zhenyuzh@umich.edu, Hyun-Soo Ahn, Christopher Ryan, Joline Uichanco

With the rise of social technologies, the traditional view of treating consumers as isolated entities no longer holds for some markets. For instance, in influencer-driven commerce markets, social media platforms can significantly accelerate new product adoptions to create fast-moving markets with demand hype. We propose a dynamic pricing model for the setting where future demand is dependent on current and past adoptions. In this setting, price not only affects the current revenue and sales, but also, the future demand pattern and revenues. We propose a certainty equivalent (CE) policy (pricing and initial inventory) with re-optimization and show that this policy is asymptotically optimal.

3 - Revenue Management with All-or-Nothing Constraint

Longyuan Du, University of San Francisco, San Francisco, CA, 94117, United States, ldu5@usfca.edu, Ming Hu, Jiahua Wu

We consider a revenue management problem under the all-or-nothing constraint. The seller will receive her revenue if and only if the number of sales exceeds a predetermined sales target at the end of sales horizon. Over the course of the sale horizon, the sales process can be moderated by the seller though her costly effort. We show that the optimal sales rate is not monotone with respect to the remaining time or the number of sales required to reach the target. We then study easy-to-compute heuristics that can solve the problem efficiently. We propose a modified resolving heuristic and show that it is asymptotically optimal, and achieves a logarithmic performance loss.

■ TE56

CC- Skagit 5

Marketing II

Contributed Session

Chair: Dilek Günneç, Özye in University

1 - The Effects of Consumption Type, Self-view, and Gender on Susceptibility to the Partner's Influence in Romantic Relationships— A Conceptual Paper

Qiuling Li, University of Macau, Macau, Macao, Chanthika Pornpitakpan

This conceptual paper aims to provide insights into how individuals' decision-making is influenced by their partners in romantic relationships. Using regulatory fit theory, it proposes several hypotheses about the interaction effects between consumption type and self-view and between consumption type and gender on susceptibility to interpersonal influence.

2 - Maximizing the Potential of Targeted Marketing: A General Framework for Customized Category Promotions in Retail

Bernhard von Mutius, WHU - Otto Beisheim School of Management, Vallendar, Germany, Arnd H. Huchzermeier

We develop the first general framework for category selection in targeted marketing based on segmenting customers in terms of churn, frequency, and loyalty. For the latter attribute, we propose a novel data-mining methodology that can distinguish between customers who shop at several retailers versus mostly at a single retailer. Using our framework, marketing managers can identify customers to target with category-specific promotions and with what objective function to target them. Our analysis reveals that the personalized targeting strategy exploits the full potential of customized marketing by optimizing the trade-off between CLV considerations and short-term campaign profitability.

3 - Mobile Targeting Effectiveness: Heterogeneity and Contingency

Zhuping Liu, Baruch College, City University of New York, New York, NY, United States

This research contributes to the literature by studying the heterogeneity and contingency of mobile targeting effectiveness. Leveraging a unique data tracking the timing and contents of each targeting message and targeted user responses, we examine how targeting effects vary across mobile devices, retailer category, and coupon characteristics. Our results reveal interesting insights which can help marketers target users at the right timing with the right contents.

4 - Influence Maximization in Social Networks under Deterministic Linear Threshold Model

Dilek Günneç, Özye in University, Istanbul, Turkey, dilek.gunnec@ozyegin.edu.tr, Furkan Gürsoy

We define the Targeted and Budgeted Influence Maximization under Deterministic Linear Threshold Model Problem and develop a novel and scalable algorithm which allows for optional methods to solve it. It is a greedy algorithm that relies on investing in potential future gains when choosing seed nodes. We suggest real-world mimicking techniques for generating influence weights, thresholds, profits, and costs. Computational experiments on four real network (Epinions, Academia, Pokec and Inploid) show that our proposed heuristics perform significantly better than benchmarks. We equip our algorithm with novel scalability methods which reduce runtime trading-off with spread performance.

■ TE57

CC- Yakima 1

Logistics III

Contributed Session

Chair: Dinghao Ma, Northeastern University, Boston, MA, 02115, United States

1 - The Use of Hybrid Crowd-sourcing Model in the Last-mile-delivery of CEP Services

Mingwei Guo, Doctoral Student, North Dakota State University, Fargo, ND, United States, mingwei.guo@ndsu.edu, Joseph Szmerekovsky

The boost of E-commerce and Cyber Sales has posted great development on the way customers shop. In the past years, third party logistics (3PL) service has been growing rapidly by the utilization of online shopping. Under dynamic business environment, such growing patterns has been initiating huge pressure on the Carrier, Express and Parcel (CEP) service. This research will be utilizing Crowd-Sourcing Logistics (CSL) tools to work with CEP last-mile delivery (LMD) to help solve the peak demand occasion problems, using conjoint analysis look into the potential reasons and causes which will trigger CSL, as well as working as a partnership for the improvement of the entire CEP logistics dynamics.

2 - Managing Drones and Battery Inventories on Last-mile Logistics under Uncertainty

Ali Tolooie, PhD Candidate and Graduate Research Assistant, Kansas State University, Manhattan, KS, United States, alit@ksu.edu, Ashesh Sinha

Nowadays, last-mile logistics using drones present practical applications in various industries. However, limited and uncertain flight range of a large fleet of drones and randomness in demand creates a complex issue in last mile logistics. Using stochastic models and concept of Matrix Geometric approach, we provide exact analysis on the logistics and inventory decisions.

3 - With a Little Help from My Truck: Parcel Delivery Assisted by Autonomous Vans

Stefan L. Fedtke, Friedrich-Schiller-Universität Jena, Jena, Germany, Nils Boysen

Especially in urban areas, the implementation of last-mile logistics is associated with high efforts and costs for companies, customers, and the environment. Managing the increasing amount of parcel deliveries without negative effects such as congestions, pollution, and disgruntled customers turns out as a challenging task. This talk addresses an innovative solution concept, i.e., autonomously driving delivery vans, and their effects on last-mile logistics. We discuss different aspects on how self-driving vans can assist a human delivery person, introduce respective optimization problems, formulate mathematical models, and suggest solution procedures in order to reduce delivery time.

4 - Last Mile Delivery and Sharing Economy

Dinghao Ma, Northeastern University, Boston, MA, United States, ma.di@husky.neu.edu, Mehdi Behroozi

This paper tries to combine the last mile delivery and sharing economy, which crowd base drones are considered, together to decrease the last mile delivery time. A truck will first delivers all the packages in an area to the local center, next several crowd base drones will come from their origin to the center to pick up the packages and then delivery them to the customers. Tabu Search Algorithms are used to solve this NP-hard problem while sensitive analysis are made to check the influence of different speed ratio of drones and trucks, and the influence of number of drones in that area.

■ TE58

CC- Yakima 2

Disaster Management in Preparedness, Response and Recovery

Sponsored: Public Sector OR

Sponsored Session

Chair: Kyoung Yoon Kim

1 - An Integrated Optimization Framework in Modeling Patient Evacuation Before Hurricanes

Kyoung Yoon Kim, University of Texas at Austin, Austin, TX, United States, erickim@utexas.edu, Erhan Kutanoglu, John Hasenbein

We propose an integrated optimization framework in modeling patient evacuation before hurricanes. First, in order to capture the probabilistic nature of hurricanes, we generate hurricane scenarios by parameterizing the hurricane forecasts and generating the multiple inundation maps using the state-of-art hydrology and hydraulics models. Then, we input the scenarios into a stochastic integer program to make decisions on patient movements, staging area locations and positioning of emergency medical vehicles.

2 - Post-disaster Joint Repair of Road and Power Networks

Erhan Kutanoglu, University of Texas-Austin, Or/Ie Graduate Program, Dept of Mechanical Engineering, Austin, TX, 78712, United States, Brian French

This presentation covers the interaction between the competing desires of road and power grid repair agencies in the wake of a hurricane. We formulate integer programming models for both aspects of the problem and partially relax the routing aspects to make them computationally tractable. A framework is presented to iterate between the two solutions to find a solution that meets both objectives.

3 - Resilient Transportation Networks with Humanitarian Logistics

Yusuf Secerdin, University of Miami, 1251 Memorial Drive McArthur, Engineer Building, Coral Gables, FL, 33146, United States, yusufsecerdin@miami.edu, Murat Erkoc

Natural disasters such as hurricanes can cause major disruptions for transportation networks. During recovery of their commercial operations, many cargo carriers are also expected and involved in logistics of humanitarian aid to disaster-stricken regions. In this study, we propose a two-stage decision framework that combines recovery of commercial transportation operations with humanitarian logistics for a cargo carrier. We illustrate our model using a case study that is based on a real transportation network in the Caribbean basin.

4 - GIS-integrated Predictive Modeling for Nursing Home Evacuation Decision

Nazmus Sakib, University of South Florida, Tampa, FL, 33612, United States, nsakib@mail.usf.edu, Kathryn Hyer, Debra Dobbs, Lindsay Peterson, Dylan J. Jester, Nan Kong, Mingyang Li

Whether to evacuate or shelter in place against hurricane is one of the most difficult and complicated decisions often encountered by nursing home (NH) administrators. There is a lack of evidence-based analytical models to inform such decision. This work proposes a GIS-integrated predictive analytics framework to improve both prediction and understanding of evacuation decision. Environmental features are extracted from rich GIS data and further integrated with various facility and resident characteristics to enhance prediction accuracy. A real-world case study is provided to investigate the multi-factorial and nonlinear nature of NH evacuation decision in a real application context.

5 - Proactive Planning for Slow Onset Weather Event

Mahsa Ghanbarpour, Northeastern University, Boston, MA, 02115, United States, ghanbarpourmamagh.m@husky.neu.edu, Ozlem Ergun

Preparedness and response planning are necessary to reduce the adverse impacts of severe weather and other environmental emergencies. This study introduces a decision-making framework that optimizes the level and timing of proactive actions in healthcare by analyzing the trade-offs between making more accurate decisions with better weather forecasts vs. increasing cost of action as the event approaches. We develope this framework by incorporating: (i) a pattern recognition method based on large-scale patients claim dataset for determining the impact of weather events on hospital operations and (ii) developing a stochastic dynamic programming model which captures the trade-offs.

■ TE58a

CC- Chelan 1

4:35-5:20 Responsive Learning Technologies 5:20-6:05 GoldSim

Vendor Tutorial

1 - Online Games to Teach Operations and Supply Chain Management

Samuel C. Wood, Responsive Learning Technologies, Los Altos, CA, 94022, United States

Littlefield Technologies, the Supply Chain Game, and the Sourcing Game are online competitive assignments used to teach topics including process analysis, inventory control, supply chain management, and sourcing and purchasing. We will describe the games' learning objectives, typical assignments, and actual game results.

2 - A Probabilistic Simulation Platform for Dynamically Modeling Complex Systems

Richard Kossik, GoldSim Technology Group LLC, Issaquah, WA, United States

GoldSim is a probabilistic simulation platform used for dynamically modeling complex systems. GoldSim supports decision-making and risk analysis by simulating future performance while quantitatively representing the uncertainty and risks inherent in all complex systems. The software is used primarily for engineering and scientific applications in over 60 countries worldwide.

You build a model in an intuitive manner by literally drawing a picture (an influence diagram) of your system using a collection of specialized model objects. GoldSim provides a wide variety of model objects to make models less abstract (and hence more transparent). Because the real world is inherently uncertain, GoldSim provides powerful probabilistic simulation capabilities to support representation of uncertain and/or stochastic systems. GoldSim is a hybrid simulator, allowing you to superimpose the occurrence and consequences of discrete events (e.g., financial transactions, accidents, failures) onto continuously varying systems (i.e., material and information flows). This ability, coupled with features to support the construction of hierarchical, top-down models, facilitates the simulation of large, complex systems while keeping the models easy to understand, navigate and explain to others.

Although the basic GoldSim framework is quite generic (allowing it to be used to model the behavior of nearly any kind of physical, financial or organizational system), it also provides several specialized modules to support Risk and Reliability Analysis, Financial Modeling, and Mass Transport Modeling.

GoldSim has been used for a wide range of diverse applications, ranging from modeling complex environmental systems such as mines and large water resource systems, to comparing alternative business strategies, to evaluating the risks associated with space missions. This Tutorial will provide an overview of GoldSim's features and capabilities and illustrate a number of existing applications.

■ TE59

CC- Chelan 2

Joint Session QSR/Practice Curated: Advances in the Gaussian Process

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Raed Al Kontar

1 - Mapping Based Additive Gaussian Process with Sequence Order Inputs

Xinwei Deng, PhD, Virgina Tech, Blacksburg, VA, United States, Qian Xiao, Abhyuday Manda

In modern pharmaceutical industry, combinatorial drugs have been widely applied in disease treatment, especially chemotherapy for cancer, where both the dosage and order-of-addition of each drug component are important. In this work, we propose a novel Mapping-based Additive Gaussian Process (MaGP) model to provide both accurate predictions and clear interpretations. The proposed method is an efficient probabilistic model of complex input-output relationship to guide the searching for optimal solutions, e.g. the optimal drug dosages as well as orders-of-addition for combinatorial drugs. We illustrate our method via two real drug experiments on lung cancer and several simulation studies.

2 - Gaussian Processes Interpolation with Matérn Kernels: Uniform Convergence and Robustness

Rui Tuo, Texas A&M University, College Station, TX, United States, ruituo@tamu.edu, Wenjia Wang

We derive some non-asymptotic error bounds for the prediction error under the uniform metric when the spectral densities of both the true and the imposed correlation functions decay algebraically. The Matérn families is a prominent class of correlation functions of this kind. We show that, when the smoothness of the imposed correlation function exceeds that of the true correlation function, the prediction error becomes more sensitive to the space-filling property of the design points. We also derive a lower bound of the prediction error and show that the kriging predictor reaches the optimal rate, if the experimental design scheme is quasi-uniform and the correlation function is oversmoothed.

3 - Variational Inference of Joint Model Using Multivariate Gaussian Convolution Process

Xubo Yue, University of Michigan, Ann Arbor, MI, United States, maxyxb@umich.edu

We present a prognostic framework for individualized event prediction based on joint modeling of both longitudinal and survival data. Our approach exploits a multivariate Gaussian convolution process (MGCP) to model the evolution of longitudinal signals and a Cox model to map survival data with longitudinal data modeled through the MGCP. Taking advantage of the structure imposed by convolved processes, we provide a variational inference framework to simultaneously estimate parameters in the model. This reduces computational complexity and safeguards against model overfitting. Experiments show that our framework outperforms state-of-the art approaches built on two-stage inference.

4 - Distributed Multivariate Gaussian Processes

Raed Al Kontar, University of Michigan, IOE 2769, Ann Arbor, MI, 48109, United States

We present a generic distributed estimation scheme for functional data that scales efficiently to high dimensions and minimizes the negative transfer of knowledge between uncorrelated functional outputs is proposed. Consistency in estimation and variable selection (oracle property) are then established. The methodologies are validated using numerical studies and a case study with real world data in the application to cloud-based vehicle health monitoring service systems.

■ TE60

CC- Chelan 4

Data Science for Disaster Management

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Youngjun Choe, University of Washington, Seattle, WA, 98105, United States

1 - Tweet Diffusion Life-cycle: A Twitter Tale of Hurricanes

Ridwan Al Aziz, University at Buffalo, The State University of New York, Buffalo, NY, United States, ridwanal@buffalo.edu, Jun Zhuang

Online social media (OSM) has become a popular platform for people to share information on diverse topics. OSM has been widely used as an information dissemination agent, particularly during crisis situations such as hurricanes, earthquakes, floods or political conflicts. This paper studies the temporal tweet behavior of people during hurricanes and determines the data diffusion trends. A novel concept of “Tweet Diffusion Life-cycle” is introduced which will help to determine the efficient timing of tweeting life-saving critical information during hurricanes for the responsible agencies.

2 - Modeling Uncertain and Dynamic Interdependencies of Infrastructure Systems with Stochastic Block Model

Jin-Zhu Yu, Vanderbilt University, Nashville, TN, 37212, United States, yujinzhu88@gmail.com, Hiba Baroud

Modeling the resilience of interdependent critical infrastructure (ICI) requires a careful assessment of interdependencies as these systems become interconnected. The interdependency across ICIs are often subject to uncertainty due to lack of data. This paper develops an approach to modeling the interdependency of ICIs with probabilistic graphical models. Specifically, the approach estimates the probability of links between individual systems considered as blocks in the stochastic block model. The proposed model uses several nodal attributes as predictors. The proposed approach is illustrated with a case study of the interdependent water and power networks in Shelby County, Tennessee.

3 - Data Simulation to Support Interdependence Modeling of a Multimodal Transportation Network

Basem Alkhaleel, University of Arkansas, Fayetteville, AR, 72701, United States, baalkhal@email.uark.edu, Jose Azucena

In this research, data about natural extreme events affecting inland waterways are collected and used to predict possible occurrences of such events in the future using spatio-temporal statistical models. A simulation tool built on these statistical models is used to investigate the effect of waterways disruptions on interconnected transportation systems. A case study based on the Mississippi River and the McClellan-Kerr Arkansas River Navigation System (MKARNS) is provided to illustrate the use of the simulation tool in interdependence modeling and decision making for the operation of a multimodal transportation network.

4 - Personal Fitness Monitoring App Data to Assess Community Recovery at Scale: Case Study on Post-hurricane Harvey Recovery of Harris County, Texas

Zhanlin Liu, University of Washington, Seattle, WA, 98105, United States, zhanlliu@uw.edu, Pariyakorn Maneekul, Scott Miles, Nicole Errett, Youngjun Choe

During the disaster recovery process, it is challenging to continuously assess community health and well-being. This study used cycling and running activity records from a personal fitness monitoring app as a proxy for community health and wellbeing. This large-scale data enabled us to assess the post-Hurricane Harvey recovery of the fitness activity level throughout Harris County, Texas. The data revealed geospatial patterns of fitness activity level recovery and demonstrated its value in supporting a near real-time, scalable method to monitor the recovery of affected communities.

5 - Hurricane-damaged Building Identification Using Satellite Imagery and Geographical Features

Quoc Dung Cao, University of Washington, Seattle, WA, 98105-0002, United States, Youngjun Choe

Rapid damage assessment after hurricane events using satellite imagery has the potential to transform emergency response to the events. However, relying solely on the imagery would underutilize valuable geographical features such as locality of the buildings, ground elevation, and flood inundation risk. We study the contribution of each feature to the improvement of damaged building identification task using the convolutional neural network. The proposed method is applied to the case study of 2017 Hurricane Harvey.

■ TE61

CC- Chelan 5

Smart Manufacturing Systems: Challenges, Opportunities, and Solution Methodologies

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Mohammed Shafae, University of Arizona, Tucson, AZ, 85721, United States

1 - Data-informed Decision Process for the Polishing Process of 3D Printed Titanium Alloy Parts

Shilan Jin, Texas A&M University, College Station, TX, United States, jin0541@tamu.edu, Yu Ding, Satish Bukkapatnam, Asif S. Iquebal

Polishing is a crucial post-processing step to finish additive manufacturing products. Important decisions in polishing operations, such as pad changing and ending point determination, currently rely on practitioners’ experience and subjective visual inspection of surface quality. For delivering consistency and reducing variability, Gaussian process model-guided decision making is developed for the polishing process of a Titanium alloy product. The series of Gaussian process models appear capable of capturing surface changes and variation over the polishing process, resulting in a decision protocol informed by the correlation characteristics over the sample surface.

2 - Opportunities and Challenges of In-Situ Monitoring in Additive Manufacturing

Marco Grasso, Politecnico di Milano, Via La Masa 1, Milano, 20156, Italy, marcoluigi.grasso@polimi.it, Bianca Maria Colosimo

This talk revises exiting solutions for in-situ monitoring of Additive Manufacturing via signal, image and video-image data. Appropriate methods for statistical data modelling and monitoring are discussed.

3 - Spatiotemporal Gaussian Process for Image Guided Quality Control of Additive Manufacturing

Farhad Imani, The Pennsylvania State University, State College, PA, 16802, United States, fxi1@psu.edu, Ruimin Chen, Hui Yang

Additive manufacturing (AM) is a new paradigm in a design-driven build of customized products. Nonetheless, AM quality assurance is extremely challenging due to the existence of multiple factors that impact the quality of a build. The proposed research introduces a novel real-time and sparse spatiotemporal Gaussian process (STGP) which approximates a standard layerwise profile while quantifying the spatiotemporal deviations from the standard. Experimental results show that the proposed STGP methodology is highly effective to monitor the quality of layerwise images. This provides a significant opportunity to reduce inter-layer variation in AM prior to completion of a build.

4 - Gauge Capability Studies for High-density Data

Romina Dastoorian, Western Michigan University, Kalamazoo, MI, 49009, United States, romina.dastoorian@wmich.edu, Lee Wells

In manufacturing, advanced measurement systems are continually being incorporated into modern SPC systems. Significant amount of research efforts has been placed in the development of Phase I and II SPC tools. However, the study of the quality and adequacy of a measurement system which is a prerequisite to implementing any SPC tool; has mostly been neglected for high-density (HD) data. Therefore, this work performs a holistic Gauge study on HD data by using spatial statistics data models. The main objectives of this work are listed as: 1) Studying how to analyze the repeatability and reproducibility of HD data, 2) Quantifying the uncertainty associated with measurement systems from multiple factors.

5 - Physics-based Detection of Cyber-Attacks on Cyber-Physical Manufacturing Systems

Mohammed Shafae, University of Arizona, Tucson, AZ, 85721, United States, shafae1@email.arizona.edu

Modern manufacturing systems face an unprecedented threat of cyber-physical attacks due to the increased connectivity between manufacturing systems entities. This work introduces a fundamental theory to understand cyber-physical attack designs and implementation approaches. Through this fundamental theory, a systematic method was developed to identify the elements of attack design and implementation space. In addition, a designation system was created to enumerate all possible approaches to design and implement attacks on part quality. The use of this method is demonstrated through several experimental machining case-studies covering a wide variety of unique attack scenarios.

■ TE62

CC- Tahoma 1

Empowering Smarter Healthcare Decisions Using Operations Research and Data Analytics

Sponsored: Health Applications

Sponsored Session

Chair: Sharan Srinivas, University of Missouri, Columbia, MO, 65211, United States

1 - Predicting Patient Punctuality Using Machine Learning Algorithms

Sharan Srinivas, University of Missouri, Department of Industrial and Manufacturing, Systems Engineering, Columbia, MO, 65211, United States, srinivassh@missouri.edu

Late patient arrivals in outpatient clinics disrupt the schedule, increase subsequent patient’s waiting time and decrease physician productivity. This research aims to predict the patient-specific risk of tardy arrival based on several pertinent variables. Four machine learning algorithms are built to conduct a comparative analysis of predictive performance. The models are tested using real data obtained from two outpatient clinics. Gradient boosting machine yielded the best predictive performance (Clinic1 AUC = 0.904 and Clinic2 AUC = 0.863). Further, insights drawn from our analysis will enable healthcare administrators to manage and mitigate late arrivals.

2 - Positional Flexibility and Consistent Assignment in Long-Term Care Staffing

Vincent Slaugh, Cornell University, Ithaca, NY, United States, vws8@cornell.edu, Alan Scheller-Wolf

We study the assignment of caregivers to residential households for each shift. We show that prioritizing part-time employees to work in their “home unit” can significantly improve consistency of care. Analysis of one facility’s schedules reveals a 40% possible reduction in the number of unique caregivers assigned to each household.

3 - Evaluation of Dexketoprofen Trometamol Efficacy in Postoperative Pain Management for Open Heart Surgery

Umit Tursun

Please check the mobile app for this abstract.

4 - A High-Fidelity Model to Predict Length-of-Stay in the Neonatal Intensive Care Unit (NICU)

Kanix Wang, University of Chicago Booth School of Business, Chicago, IL, 60637, United States, Kanix.Wang@chicagobooth.edu, Walid Hussian, John R. Birge, Michael D. Schreiber, Daniel Adelman

The widespread implementation of electronic medical record systems has enabled hospitals to collect massive amounts of health data. To integrate this data into healthcare operations, we impose expert knowledge when grouping raw clinical data into medically meaningful variables, which summarize patients’ health trajectories. We use dynamic predictive models to output patients’ remaining lengths of stay, future discharges, and census probability distributions based on their health trajectories up to the current stay. Evaluated with large-scale EMR data, our model significantly improves the predictive power and remains medically interpretable.

■ TE63

CC- Tahoma 2

Simulation Models in Healthcare

Sponsored: Health Applications

Sponsored Session

Chair: Pinar Keskinocak, Georgia Institute of Technology, Atlanta, GA, 30332, United States

Co-Chair: Tyler Perini, Georgia Institute of Technology, Atlanta, GA, 30324, United States

1 - The Role of Model Structure in Predicted Effectiveness of Policy Interventions for Infectious Diseases

Giovanni S. Malloy, Stanford University, Stanford, CA, United States, malloyg@stanford.edu, Jeremy D. Goldhaber-Fiebert, Eva A. Enns, Margaret L. Brandeau

We analyze the role of model structure in determining the predicted effectiveness of policy interventions for infectious diseases such as HIV. We create four models which vary with respect to population mixing (compartmental vs. network structure) and risk stratification (uniform vs. stratified risk). We calibrate the four models to the same baseline prevalence and then evaluate the effects of a simple policy intervention. The observed differences between the model outputs suggest the need for careful consideration of model structure when modeling interventions to control infectious diseases.

2 - Human Mobility and Infectious Disease Dynamics

Amy Wesolowski, Johns Hopkins Bloomberg School of Public Health, Batlimore, MD, United States

Infectious disease transmission depends on the dynamics of human movement. However, in many settings there is limited data to quantify human travel patterns on spatial and temporal scales relevant to disease control. Increasingly novel data sources are available, such as mobile phone calling records, that can be used to understand the impact of travel on disease dynamics and can provide additional information about human mobility. We will outline work done to analyze various sources of travel data, the utility of these data to understand directly-transmitted and vector-borne disease dynamics, and models developed to capture epidemiologically relevant mobility patterns.

3 - Physical-statistical Modeling and Optimization of Complex Systems with the Application in Healthcare

Bing Yao, PSU, State College, PA, 16801, United States, Hui Yang

This talk will present a novel physics-driven spatiotemporal regularization method for high-dimensional predictive modeling in complex healthcare systems. This model not only captures the physics-based interrelationship between time-varying explanatory and response variables that are distributed in the space, but also addresses spatial and temporal regularizations to improve the prediction performance.

4 - Use of Simulation to Investigate Effects of Distributions on Pancreatic Cancer Progression Model

Julie Simmons Ivy, North Carolina State University, Raleigh, NC, Lena Abu-El-Haija, Osman Ozaltin, Walter G. Park

Pancreatic cancer is a low-incidence disease, where tumor progression studies using patient longitudinal data had limited sample sizes. Estimating the tumor inverse growth rate and its distribution are a challenge. Pancreatic cancer progression models were built as a function of age, race, and gender under Uniform and Gamma inverse growth rate distributions. This study uses simulation to evaluate the effect of the tumor inverse growth rate distribution on tumor progression. The tumor timeline was found to be nine months longer with the Gamma assumption. It was inconclusive whether tumor progression is faster in older patients with the different underlying assumptions on the inverse growth.

■ TE64

CC- Tahoma 3

Optimizing Healthcare Operations

Sponsored: Health Applications

Sponsored Session

Chair: Kimia Ghobadi, MIT, Cambridge, MA, 02142, United States

1 - Introducing Swing Shifts to Dynamically Respond to Emergency Department Workload Uncertainty

David L. Kaufman, University of Michigan - Dearborn, Fairlane Center South, Dearborn, MI, 48126, United States, davidlk@umich.edu, Jianing Man, Kalyan Pasupathy, Daniel Cabrera, Mustafa Y. Sir

A fundamental problem of emergency care is matching resources to uncertain patient demands. Staffing allocation decisions require good matching with workloads but also consider the needs of emergency providers at very high risk of burnout. Mayo Clinic Emergency Department recently introduced a "swing shift," which allows physicians to leave early depending on a workload threshold. While popular, swing shifts introduce several challenges: How to design a threshold mechanism? What is the optimal length of the furlough? When should these shifts start and what is their impact? We introduce an effective and tractable data-driven optimization model for a complex stochastic problem.

2 - Optimizing Lung Transplantation Waitlist Composition from the Transplant Program's Perspective

David Mildebrath, Rice University, Houston, TX, 77005, United States, dtm3@rice.edu, Taewoo Lee, Andrew J. Schaefer

Under regulations by the Centers for Medicare and Medicaid and Organ Procurement Transplantation Network, the United States has seen a rise in risk-adverse behavior among transplant programs, resulting in an increase in organ discard rate. In this work, we optimize the mix of patients on the transplant waitlist to maximize transplantation volume and manage the risk of penalization under the regulations. We present a chance-constrained mixed-integer program for the waitlist composition problem and derive analytical results to provide clinical insight on the decision-making process. Our tractable approximation model provides the first qualitative comparison between different regulations.

3 - A Bayesian MCMC Model to Study the Spread of Antibiotic-Resistant Bacteria in the Hospital

Diego A. Martinez, Johns Hopkins University, 1800 Orleans Street, Billings Building 401E, Baltimore, MD, 21287, United States, Katherine E. Goodman, Rajib Paul, Jeremiah S. Hinson, Aria Smith, Matt Toerper, Scott R. Levin, Patricia J. Simner, Justin Lessler, Aaron M. Milstone, Eili Y. Klein

Spread of antibiotic-resistant bacteria that cause healthcare-associated infections is an enduring problem linked with high mortality and morbidity. There is debate on the value of interventions that target specific pathogens such as carbapenem-resistant organisms (CRO). We used temporal networks of the location of patients within the hospital to model a patient's risk of CRO acquisition, and to determine the impact of contact precautions on this risk while adjusting for healthcare worker-mediated connectivity, colonization pressure, carbapenem use, hand hygiene, and environmental cleaning.

4 - Readmission Risk Trajectories for Heart Failure Patients Using a Dynamic Prediction Approach

Sauleh Ahmad Siddiqui, Johns Hopkins University, 3400 N. Charles Street, Baltimore, MD, 21218, United States, siddiqui@jhu.edu

We develop a dynamic readmission risk prediction model that yields daily predictions for hospitalized heart failure patients toward identifying risk trajectories over time and identify clinical predictors associated with different patterns in readmission risk trajectories. A two-stage predictive modeling approach combining logistic and beta regression was applied to electronic health record (EHR) data accumulated daily to predict 30-day readmission for a cohort of 534 heart failure patient encounters over 2,750 patient-days. Unsupervised clustering was performed on predictions to uncover time-dependent trends in readmission risk over the patient's hospital stay.

■ TE65

CC- Tahoma 4

Appointment System and Physician Behavior

Sponsored: Health Applications

Sponsored Session

Chair: Aditya Jain, Baruch College, Zicklin School of Business, New York, NY, 10010, United States

1 - Wait and Then Hurry Up. The Effect of Flexible Service Rates in Appointment Scheduling Systems

Aditya Jain, Baruch College, Zicklin School of Business, New York, NY, 10010, United States, aditya.jain@baruch.cuny.edu, William P. Millhiser

Recent empirical evidence suggests that ambulatory care healthcare workers intentionally vary service rates in response to two factors: time of day and queue length, where workers choose work speeds to balance their own overtime and the patient's wait. We explore a theoretical justification of this behavior and show that workers speed up if the cost of patient waiting is relatively small compared to workers' overtime cost. We analyze the implications of such worker behavior on various performance metrics for established appointment systems, and how appointment systems should be adapted.

2 - Capacity Planning for Post-discharge Follow-up

Alex Mills, Baruch College, City University of New York, New York, NY, 10010, United States, Alex.Mills@baruch.cuny.edu, Jonathan Helm

Many hospitals now schedule patients for follow-up care at the time of discharge, in an effort to reduce readmissions. We show that careful capacity planning is needed to make a follow-up program effective.

3 - Appointment Scheduling: The Disconnect Between Theory and Practice

William P. Millhiser, Zicklin School of Business, Baruch College, One Bernard Baruch Way, New York, NY, 10010, United States, william.millhiser@baruch.cuny.edu, Emre Veral

We explore the potential for theory-driven appointment schedules to make significant improvements in operational outcomes for medical practices. Our results show that potential benefits may fail to make a strong enough business case for adopting complex scheduling systems. IT integration difficulties, centralized processes, and staff buy-in exacerbate misgivings for adoption.

4 - Managing Interruptions in Appointment Schedules in Physician Clinics

Ali Dogru, University of Southern Mississippi, Hattiesburg, MS, United States, ali.dogru@usm.edu, Sharif Melouk

Physician clinics often encounter interruptions that affect their operations and impact the patient experience. Thus, in this research, we develop an interruption management procedure employing real-time patient notification. We use stochastic optimization to determine optimal appointment intervals and simulation optimization to establish a notification policy. Experimentation provides managerial insights. Keywords: Appointment Scheduling, Interruptions, Patient Notification, Simulation Optimization, Stochastic Optimization.

■ TE66

CC- Tahoma 5

Joint Session QSR/DM: Improving Machine Learning Algorithms for Causal Inference

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Arman Sabbaghi, Purdue University, West Lafayette, IN, 47907, United States

1 - Controlling Confounding and Selection Biases in Causal Inference

Elias Bareinboim, PhD, Purdue University, West Lafayette, IN, 47907, United States, eb@purdue.edu

One of the fundamental challenges in scientific endeavors is the systematic discovery of cause and effect relations from a combination of non-experimental data and substantive knowledge about the phenomenon under investigation. Two of the most common obstacles to inferring these relations appear in the form of two biases, namely, confounding and selection. In this talk, I briefly describe a general solution on how to infer causal effects when these biases are simultaneously present. This approach generalizes the pervasive and celebrated strategies such as the Backdoor criterion and Inverse probability weighting (IPW).

2 - Transfer Learning for Estimating Causal Effects Using Neural Networks

Jasjeet Sekhon, PhD, University of California, Berkeley, CA, United States, Bradley Stadie, Sören R. Künzel, Nikita Vemuri, Varsha Ramakrishnan, Pieter Abbeel

We develop new algorithms for estimating heterogeneous treatment effects, combining recent developments in transfer learning for neural networks with insights from the causal inference literature. By taking advantage of transfer learning, we are able to efficiently use different data sources that are related to the same underlying causal mechanisms. We compare our algorithms with those in the extant literature using extensive simulation studies based on large-scale voter persuasion experiments and the MNIST database. Our methods can perform an order of magnitude better than existing benchmarks while using a fraction of the data.

3 - Collaborative Design for Improved Causal Machine Learning on Big Observational Data

Yumin Zhang, Purdue University, West Lafayette, IN, 47907, United States, zhan2013@purdue.edu, Arman Sabbaghi

The successful application of machine learning for inferring causal effects from an observational study requires consideration of the design of the observational data. In general, the workload of designing a study with high dimensional covariates could be unwieldy for a single researcher. We propose a framework to match or subclassify subjects in such an observational study based on the collaborative efforts of multiple analysts, and to infer causal effects via the application of flexible machine learning algorithms to the designed study. Ultimately, our framework reduces the workload of each study designer, and enables improved causal machine learning from large observational studies.

4 - Black Box Methods for Causal Inference: Lessons Learned from the 2016 ACIC Data Analysis Competition

Vincent Dorie, Associate Research Scientist, Columbia University, New York, NY, United States, vdorie@gmail.com, Jennifer Hill, Uri Shalit, Marc Scott, Dan Cervone

The comparison of causal inference methods is complicated by the requirement of foundational assumptions, leading to a reliance on simulation. However, methods are rarely compared on equal footing as it is difficult to create plausible-yet-interesting simulations and to best apply a competitor's work. The simulations generated by the data analysis challenge of the 2016 Atlantic Causal Inference Conference provide a way for developers to evaluate their methods, compare them to their competitors, and create default implementations for applied researchers. Here, we review the structure of that competition, its results, and what we've learned about causal inference methodology since.

■ TE67

S- Virginia

Simulation Optimization

Sponsored: Simulation

Sponsored Session

Chair: David J Eckman, Cornell University, Ithaca, NY, 14850, United States

Co-Chair: Shane Henderson, Cornell University, Ithaca, NY, 14853, United States

1 - Ranking and Selection under Input Uncertainty

Enlu Zhou, Georgia Institute of Technology, Atlanta, GA, 30332-0205, United States, enlu.zhou@isye.gatech.edu, Di Wu

We study ranking and selection (R&S) under input uncertainty (IU) by allowing the possibility of acquiring additional data. Two classical R&S formulations are extended to account for IU: (i) for fixed confidence, we consider when data arrive sequentially so that IU can be reduced over time; (ii) for fixed budget, a joint budget is assumed to be available for both collecting input data and running simulations. New procedures are proposed for each formulation using the frameworks of Sequential Elimination and Optimal Computing Budget Allocation, with theoretical guarantees provided accordingly.

2 - Convergence Rates of Global Optimization under Randomized Sampling

Jialin Li, PhD Candidate, University of Maryland, College Park, MD, United States, jl233@math.umd.edu, Ilya O. Ryzhov

We propose a new way of approaching global (black-box) optimization in a high-dimensional setting. Rather than developing new adaptive algorithms, we consider the design of static policies based on randomized sampling, by analogy with the literature on sampling laws for ranking and selection. We report our progress on the theoretical analysis of the convergence rates of such policies.

3 - Best Arm Identification and Hypothesis Testing in Very Large Action Spaces

Kevin Jamieson, University of Washington, Seattle, WA, United States, jamieson@cs.washington.edu

In multi-armed bandits, to identify a single good alternative among many sub-optimal alternatives, the number of total measurements necessarily scales linearly with the total number of alternatives. However, if many of the alternatives (e.g., a constant fraction) are "good enough" then far fewer measurements may be necessary to find one of them. Indeed, if half of the alternatives are good, then a random sample of constant size of them should contain at least one good enough alternative. In this talk I will ground this intuition in a theoretical framework known as infinite armed bandits and describe applications.

4 - Posterior-Based Stopping Rules for Bayesian Ranking-and-Selection Procedures

David J. Eckman, Northwestern University, Evanston, IL, 14850, United States, Shane Henderson

Ranking-and-selection procedures deliver Bayesian guarantees by repeatedly evaluating a posterior quantity of interest - e.g., the posterior probability of correct selection or expected opportunity cost - and terminating when this quantity crosses some threshold. Motivated by settings in which there are many alternatives, we develop several methods for improving the computational efficiency of checking such stopping rules. Simulation experiments give a sense of the savings in the number of observations taken relative to existing procedures that instead use cheaply computable bounds on the posterior quantity of interest.

■ TE68

S- University

Joint Session Sharing Econ & Crowdsourcing/MSOM/SERV OP/Practice Curated: Operational Flexibility in On-Demand Services

Emerging Topic: Sharing Economy & Crowdsourcing

Emerging Topic Session

Chair: Daniel Freund, Cornell University, Ithaca, NY, 14850, United States

1 - Understanding the Value of Large Time Windows in Scheduled Delivery Problems

Yeqing Zhou, Columbia University, 550 W. 120th St, New York, NY, 10027, United States, yz2714@columbia.edu, Adam Elmachtoub

Online grocers sell groceries online and provide a menu of time windows for customers to select a specific one to receive their delivery. We study the benefit of consumer flexibility in online grocery industry by offering large time windows (LTW) which can improve the delivery capacity utilization. We compare consumer flexibility with process flexibility and discover similar properties such as limited flexibility is good enough in both settings. However, chain structure is not essential in consumer flexibility due to the lack of submodularity and we conclude that non-overlapping LTWs can capture most of the benefits.

2 - Balancing Supply and Demand: Queuing Versus Surge Pricing Mechanisms

Yueyang Zhong, University of Chicago, Booth School of Business, Chicago, IL, United States, yzhong0@chicagobooth.edu, Zhixi Wan, Zuo-Jun Max Shen

At the end of 2017, DiDi Express replaced "surge pricing" mechanism by "observable queue" mechanism in a number of cities across China due to the uncertainty of surge pricing. In order to compare these two mechanisms, we build an M/M/s+M queueing model with balking and reneging and analytically and numerically find insightful results regarding consumer surplus, GMV, demand satisfaction rate and fairness. Using DiDi's real data, we implement a case study in Beijing and further statistically find correlations between system efficiency and driver's idleness.

3 - The Inefficiency of Dynamic Pricing in Ridesharing Systems

Garrett van Ryzin, Columbia University, New York, NY, United States, Daniel Freund

We identify a fundamental inefficiency of dynamic pricing and dispatch in ridesharing systems that is created by current market designs. We analyze the resulting inefficiencies using a fluid model and suggest an alternate mechanism that provably increases throughput. We complement our theoretical results through numerical experiments.

4 - Escrow Payment: A Smoother Driver Pay Mechanism

Arash Asadpour, Lyft inc., Stern School of Business, Kaufman Management Center, New York, NY, 10012, United States, aasadpour@lyft.com, Daniel Freund, Garrett J. van Ryzin

Dynamic pricing is a frequently used tool to match supply and demand in the gig economy. The comparatively fast-paced dynamics of supply and demand have also led to dynamic pricing featuring prominently in the recent operations research literature. In practice, ridesharing platforms like Lyft and Uber no longer employ the strictly proportional commission. Further, beyond the driver's expected pay, the volatility in prices affects drivers' decision-making. We discuss a mechanism to smooth the driver's dynamic pay and analyze its properties in a stylized stochastic setting. We demonstrate both numerically and analytically the characteristics of the mechanism and discuss its potential benefits.

■ TE69

S- Seneca

Telecommunications and Network Analytics – I

Sponsored: Telecommunications and Network Analytics

Sponsored Session

Chair: Hosseinali Salemi, Oklahoma State University, Stillwater, OK, 74075, United States

1 - Optimal Sensor Placement: Power Domination, Set Covering, and Zero Forcing Forts

Logan A. Smith, Rice University, Rice University, Houston, TX, United States, logan.smith@rice.edu, Illya V. Hicks

To monitor electrical activity throughout power grids, sensors known as phasor measurement units can installed. Due to implementation costs it is desirable to minimize the number of sensors deployed, while ensuring that the grid can be effectively monitored. This optimization problem motivates the graph theoretic power dominating set problem. We propose a novel IP for identifying minimum power dominating sets by formulating a set cover problem. This problem's constraints correspond to neighborhoods of zero forcing forts; we show that they can be effectively separated and that this approach consistently improves upon the runtime performance of the state of the art method by an order of magnitude.

2 - A Local Search Method for the Maximum Induced Cluster Subgraph Problem

Seyedmohammadhossein Hosseinian, Texas A&M University, College Station, TX, 77843-3131, United States, hosseinian@tamu.edu, Sergiy Butenko, Richard Forrester, Fred W. Glover

A cluster graph is a graph whose every connected component is a complete graph. Given an input graph, the maximum induced cluster subgraph problem, which finds applications in network-based data analysis, is to find a maximum-cardinality subset of vertices inducing a cluster graph. We present a local search method based on a (cubic) pseudo-Boolean formulation of this problem. The advantage of this method is its ability to evaluate complex local moves in a very efficient manner. We use this method within a metaheuristic procedure for the maximum induced cluster subgraph problem, and present the results of our computational experiments.

3 - A Branch-and-cut Algorithm for the Distance-based Critical Node Problem

Hosseinali Salemi, Oklahoma State University, Stillwater, OK, 74075, United States, hosseinali.salemi@okstate.edu, Austin Buchanan

Recently, researchers have studied the problem of identifying so-called "critical nodes" in a network, which are small subset of nodes whose deletion maximally reduces some connectivity metric. In this talk, we consider a class of this problem in which the task is to delete at most b nodes so as to minimize the number of node pairs that remain connected by a path of length at most k. We propose new IP formulations and a preprocessing procedure. Also, we compare our results with previous approaches.

■ TE70

S- Jefferson A

Finance and Entrepreneurship

Contributed Session

Chair: Ricarda Bouncken, University of Bayreuth, Prieserstr 2, Bayreuth, 95444, Germany

1 - Risk Culture in the Insurance Industry: A Machine Learning Approach

Abena Fosua Owusu, Rensselaer Polytechnic Institute, Troy, NY, United States, owusua@rpi.edu

Is the risk culture of insurance firms different from that of banks? In this paper, we identify the risk culture in both industries using unsupervised machine learning techniques. We use k-means clustering to group our sample of 10-K text documents into three distinct risk culture clusters: good, fair and poor risk culture groups. For both industries, we identify uncertain and litigious risk leadership and strategy features to be more defining of their risk culture. Unlike banks, we find the risk culture of insurance firms to be defined by uncertain and litigious risk training, education and recruitment features. This emphasizes the role of risk professionals like actuaries in the insurance industry.

2 - Dynamic Portfolio Optimization with Contingent Liabilities

Satya Krishna Sharma, Doctoral Scholar, BIMTECH, Noida, India, rsk.sharma_fpm18@bimtech.ac.in

Fund management problem in Agricultural insurance is two pronged problem of deciding optimal cash holdings to meet contingent liabilities while allocating rest of the funds into various assets so as to maximize the Return vs Risk ratio, over multiple time horizon.This work addresses the two pronged problem by applying extreme value theory to estimate maximum loss that could be claimed,while it uses DCC GARCH to optimize asset allocation in an ever changing investment environment.

3 - Identifying Market Manipulation & Abusive Trading Using Anomaly Detection Techniques

Robert James, PhD Student, The University of Sydney, Sydney, Australia, r.james@sydney.edu.au, Henry Leung, Artem Prokhorov

This study presents a novel semi-supervised procedure to detect intraday abusive trading in financial markets, addressing the limitations in existing rule based expert surveillance systems. We use the K-NN Dynamic Time Warping Algorithm to compute similarity scores between multivariate time series sub-sequences of trading activity. Using extreme value theory, we construct thresholds based on similarity scores observed under estimated normal trading conditions. Using real world tick data provided by a global investment bank, we highlight the utility of the procedure in identifying insider trading and demonstrate its competitiveness with respect to several benchmark algorithms.

4 - Family Firms' Digital Transformation: Insights from a Qualitative Study

Ricarda Bouncken, Prof. Dr., University of Bayreuth, Bayreuth, Germany, Beate Cesinger, Jochen Pampel, Viktor Fredrich

The present study is interested in the specifics of digital transformation. On the fundament of an explorative case study of six German family firms, we develop propositions regarding family control, openness, learning, and external sources of digitization expertise in the context family firms' digital transformation. Results indicate that that digital transformation of family firms follows specific logics. The strong influence of family ownership on mobilizing digitalization efforts, points to further theoretic development of a metastructuring perspective. In sum the the present study contributes first theoretical and practical insights on digital transformation of family firms.

■ TE71

S- Jefferson B

Joint Session BOM/Practice Curated: Behavioral Supply Chain Management

Sponsored: Behavioral Operations Management

Sponsored Session

Chair: Ozge Tuncel, PhD., Eindhoven University of Technology, Eindhoven, Netherlands

1 - Leak or Not Leak? A Behavioral Investigation of Information Leakage

Lijia Tan, Eindhoven University of Technology, Stevertsemolen, Eindhoven, 5612DT, Netherlands, ljtan.wise@gmail.com, Meng Li

We experimentally investigate an information leakage problem in supply chains where two retailers competing in a market are scouring from the same supplier. The retailer who first places an order has known the real state market while the others only know the distribution of the market states. A revenue-sharing (S) contract is considered to incentivize the supplier to not leak the information in the rational model. We design an experiment to test the performance of the S contract, while the Wholesale price (W) contact is as a benchmark. We find the S contract does not yield supply chain surplus as high as the rational model predicts.

2 - Gender Differences in Supply Chain Contracting Decisions

Ummuhan Akbay, Ozyegin University, Ozyegin Universitesi Endustri Muhendisligi, Sarigazi Vergi Dairesi 717 024 0129, Istanbul, 34794, Turkey, ummuhan.akbay@ozyegin.edu.tr

In this study we examine the effects of gender differences on contracting decisions in a simple supply chain setting consisting of a manufacturer and a retailer. The relationship between the firms is governed by a buyback contract of which the parameters are determined by the manufacturer. And the retailer is faced with a newsvendor problem. We answer the following questions: 1) How does decision maker's own gender affect contracting behavior? 2) How does the opposing decision maker's gender affect contracting behavior? 3) How does the gender composition of the supply chain affect contract efficiency?

3 - Why are Minimum Order Quantity Contracts Popular in Practice? A Behavioral Investigation

Özge Tüncel, Eindhoven University of Technology, Veelakker 36, Eindhoven, 5625 WK, Netherlands, o.tuncel@tue.nl, Niyazi Taneri, Sameer Hasija

The minimum order quantity (MOQ) contract is observed to be more popular in practice compared to other coordinating contracts. We seek to understand whether the differences in complexity across the different coordinating contracts can explain why. Using laboratory experiments, we find that subjects perform better with the MOQ contract which can be attributed to the differing cognitive burden induced by complexity and risk inherent in the different contracts; and subjects choose the MOQ contract more frequently over theoretically equivalent coordinating contracts. Our results show that the tradeoff between efficiency and complexity can be mitigated by simpler yet efficient contracts.

4 - Risk and Fairness in Channel Relationships: Evidence of Behavioral Inconsistencies

Emilio Cuilty, Amazon, Seattle, WA, United States, cuilte@amazon.com, Paola Mallucci, Jordan D. Tong

In channel negotiations there might be uncertainty that is unevenly distributed. While there is evidence that both risk preferences and fairness would matter in such contexts, there is a lack of evidence on how subjects' beliefs, risk and fairness interact. We model a wholesale pricing decision between a supplier and a retailer. We then compare the prediction of the theoretical model with data from two incentive-compatible experiments. We find that suppliers squeeze retailers more when retailers face risk. This behavior is incompatible with correct beliefs about the other players preferences. We estimate the behavioral parameters and find that suppliers underestimate retailers risk aversion.

■ TE72

S- Columbia

Digital Platforms

Sponsored: Information Systems

Sponsored Session

Chair: Ni Huang, Arizona State University, Gilbert, AZ, 85233, United States

1 - Is Uber Helping or Hurting Mass Transit? An Empirical Investigation

Yang Pan, Louisiana State University, 2208 Business Education Complex, Baton Rouge, LA, 70803, United States

Sharing economy reshapes the distribution of unused or underutilized asset through digital platforms to individuals who are willing to pay for the services. The new economy model has introduced dramatic impact on the traditional industries by matching the demand and supply in real time. In this paper, we examine how the entry of Uber, a ride-sharing services digital platform, influences the demand of public transportation. Significant debate has surrounded whether the new ride-sharing model siphoned riders from public transit, or made transit feasible for more riders. However, limited empirical research has been done to uncover whether Uber is helping or hurting public transportation systems. Leveraging a natural experiment setting, the entry of Uber, with a difference-in-differences approach, we find a significant drop in the number of passenger trips with bus. Further, our results suggest that the effect of Uber is not uniform - the reduction in bus passenger trips is mitigated when the proportion of old age people in a local urban area is large; the decrease is amplified when the populations of disable people, including with language difficulty, and self-employed people are large. However, the moderating effect of poverty is mixed.

2 - Organizational Attributes and Knowledge Sharing in Corporate Online Community

Jingchuan Pu, University of Florida, Gainesville, FL, 32607, United States, jingchuan@ufl.edu

Knowledge-sharing online communities are widely used in corporations. We empirically examine whether the organizational attributes of the knowledge seeker and provider affect the provider's knowledge sharing decisions. We find that location, hierarchical status, job similarity, and departmental position of the knowledge seeker can significantly influence whether and how the provider contribute. We also discuss the underlying mechanisms of these results.

3 - Peer Awards Increase User Content Generation but Reduce Content Novelty

Qinglai He, Arizona State University, Tempe, AZ, 85281, United States, Yili Hong, Gordon Burtch, Dokyun "DK" Lee

Platforms that depend on user-generated content spend a great deal of effort crafting policies and mechanisms that can yield a steady stream of engaging content. In this work, we consider the effects of awards offered by peers, a feature that many platforms provide to enable users to recognize the quality of peers' contributions. We conduct a large-scale field experiment on Reddit, one of the largest social news aggregation and discussion platforms in the world, evaluating the effect of peer awards (via awards) on content generation, in terms of both volume and novelty. We leverage Reddit's native peer award feature, the Gold Award, purchasing and randomly assigning Gold to more than 900 posts, anonymously, over the course of two months. Collecting and analyzing users' behavioral trace data and posting content over the period leading up to and following our treatments, via Reddit's API, we find that peer awards raise treated subjects' probability of making additional posts to Reddit by 6.6%, and lengthen subjects posts by 95.3%, on average, over the two weeks following treatment. Interestingly, however, we also observe that the content that users post under treatment exhibits greater similarity to past content (particularly the intervention post), indicating a decline in content novelty. Based on this result, we conclude that peer awards are a double-edged sword. On the one hand, per awards foster increased engagement and content production among recipients. On the other hand, the additional content that awards elicit is less novel.

4 - The Role of Participation Costs in Online Procurement Auction Performance: Evidence from an Online Labor Market

Jingbo Hou, Arizona State University, Tempe, AZ, 85287, United States, jhou27@asu.edu, Ni Huang, Yili Kevin Hong, Pei-yu Chen

Online labor markets have facilitated transactions worth billions of dollars. Yet, a noticeable inefficiency in these markets is the low matching rate. This study intends to evaluate the economic implications of the participation costs on increasing the matching rate. Our identification strategy hinges on a quasi-natural experiment on a large online service procurement platform. We theorize and empirically examine three mechanisms through which the introduction of participation costs may increase the service buyer's contract willingness: screening, effort, and selectivity.

■ TE73

S- Boren

Editor's Cut

Emerging Topic: INFORMS Section on Practice

Emerging Topic Session

1 - INFORMS Editor's Cut

Anne G. Robinson, Kinaxis, Basking Ridge, NJ, 07920, United States

Come hear from the editors of Editor's Cut! INFORMS Editor's Cut is an open access, multimedia online portal, which showcases case studies, articles, podcasts, and videos grouped by subject area, such as elections, crowdsourcing, or sports management. Have you ever wondered what it takes to be an Editor's Cut volume editor? Or are you a professor wondering how to use these cutting-edge case studies in your classroom? Perhaps you're a student needing real-world O.R. and analytics applications. On this panel, several of our editors will share their experience with you. You will learn what is openly available to you, and how to find it."“

Panelists

- Sheldon H. Jacobson, University of Illinois, Dept of Computer Science, Urbana, IL, 61801-2302, United States
- Alan Erera, Georgia Institute of Technology, Georgia Institute of Technology, Atlanta, GA, 30332-0205, United States
- Scott Nestler, University of Notre Dame, Granger, IN, 46530, United States
- Kendra Taylor, AECOM, Atlanta, GA, 30308, United States
- M. Eric Johnson, Vanderbilt University, Nashville, TN, 37203, United States
- Richard G. McGrath, United States Naval Academy, Severna Park, MD, 21146, United States
- Paul R. Messinger, University of Alberta, Edmonton, AB, T6G 2R6, Canada
- Harrison Schramm, Center for Strategic and Budgetary Assessments (CSBA), Pacific Grove, CA, 93950, United States
- Saurabh Bansal, Penn State University, State College, PA, 16801, United States

■ TE75

S- Metropolitan Ballroom A

Flash Session V

Flash Session

Chair: Lu He, Binghamton University, Mississippi State, MS, 39762, United States

1 - Inpatient Bed Management Optimization Considering Patient Flow

Lu He, Binghamton University, Vestal, NY, United States, lhe9@binghamton.edu, Sreenath Chalil Madathil, Mohammad T. Khasawneh

This study reviews 92 published papers between 2013 and 2017 on existing work in inpatient bed management and identifies research gaps following the PRISMA guideline. Inpatient bed management is an important task for hospital strategic and operational management. Hospitals in the United States usually have a dedicated bed allocation team that assigns the beds and works as a bridge between the upstream departments (such as operating rooms (OR), emergency departments (ED), and referrals) and the inpatient units for most decisions and manually allocates the rooms. An efficient inpatient bed management can not only save time and financial cost, but also increase patient safety and satisfaction.

2 - Inventory Competition in an Online Marketplace: The Impact of Traffic Channeling

Zhoupeng Zhang, Rotman School of Management, University of Toronto, Toronto, ON, Canada, Zhoupeng.Zhang19@rotman.utoronto.ca, Peiwen Yu

This paper examines the impact of online platform's Traffic Channeling (TC) mechanism on third-party sellers' inventory competition. After observing sellers' market performance in the first period, the platform allocates visitors traffic to maximize total sales in the second. We find that, TC always increases sellers' equilibrium inventory and their aggregate sales. However, TC can either increase or decrease sellers' equilibrium profits, depending on the product margin and the characteristics of demand distribution. Our work offers insights into why sellers of some product categories are hurt even when TC improves sales, and discuss implications for the designing of TC mechanism.

3 - Innovation Service Platform Based on S&T Resources for Beijing-Tianjin-Hebei, China

Ning Xiang, Beijing Science and Technology Information Research Institute, Beijing, China, xiangning_xn@163.com

Demand-oriented for the collaborative innovation and industrial development, the Innovation Service Platform based on Science and Technology(S&T) Resources for Beijing-Tianjin-Hebei in China integrates information of nine major types of S&T resources and adopts a three-integration mode, i.e. "S&T resource + digital map, internet + S&T service, expertise wisdom + intelligence forecasting" to provide big-data information service and consulting service. Based on Web GIS framework, the platform formulates data standards and constructes a "3+12" cooperation network in the region.

4 - Ladies First, Gentlemen Third! The Effect of Narrative Perspective on Medical Crowdfunding

Xitong Li, HEC Paris, Jouy-en-Josas, France, lix@hec.fr

In practice, a majority of medical fundraising campaigns are narrated from the third-person perspective without knowing whether it is the most effective approach or not. We propose that the relative effectiveness of the first- vs. third-person perspective depends on patient gender. To test the hypotheses, we conduct a randomized field experiment on a leading medical crowdfunding platform, involving more than 1.2 million potential donors. The results show that the third-person perspective is more effective in motivating donation-related behaviors for male-patient fundraising campaigns, whereas the first-person perspective is more effective for female-patient fundraising campaigns.

■ TE76

S- Metropolitan Ballroom B

Operations Management/Marketing Interface II

Contributed Session

Chair: Jing Zhou, University of North Carolina-Charlotte, Charlotte, NC, 28027, United States

1 - Block Ownership in Vertical Relationships in the Presence of Downstream Competition

Fang Fang, Cal State Los Angeles, Los Angeles, CA, United States, ffang2@calstatela.edu, Baojun Jiang, Jiong Sun

We study the economic impacts of partial vertical ownership (PVO) in the presence of downstream competition and its impact on consumer surplus. We show that both the acquiring and target firms prefer an intermediate size of PVO and consumers may get hurt in PVO by a low-valuation retailer.

2 - Partner Selection Strategies for Market Entry: Should an Entrant Firm Form an Alliance with a Major Firm, or with a Local Firm?

Kazuhiro Negoro, Keio University, Yokohama, Japan, negoro.keio@gmail.com, Nobuo Matsubayashi

In this study, we provide a game-theoretic analysis to investigate an entrant firm's partner selection for offering its new product to a market. We assume Salop's circular city market where a single major firm and two local firms exist at the center of the circle and on the circumference, respectively. We analyze two scenarios independently, where the entrant has either brand advantage or technological superiority over all of the incumbent firms. It is shown that forming a partnership with a firm who currently has the largest market share is not necessarily optimal for the entrant.

3 - Optimal Pricing Strategy Based on the Component Innovation

Weizhe Yang, University of Science and Technology of China, Hefei, China, ywz123@mail.ustc.edu.cn

Consider a two-period pricing problem for two profit-maximization firms under the following setting. While the two firms compete in the final products, the final product has a critical component which monopolized by one of them. The core component supplier can therefore firstly launch a new generation of final products in period 1 once it brings about a new generation of the key component. But for period 2, the supplier will not only determine whether to supply its competitor the newly component, but also will decide whether to sell its final product. Those two decisions lead to different competition situations. The result of our model fits the case of current smartphone market.

4 - Mobile Geo-fencing Targeting with Firms' Spatial Differentiation

Pengcheng Xia, Xi'an Jiaotong University, Xi'an, China, xiapengcheng@stu.xjtu.edu.cn, Gang Li

We investigate a competitive duopoly model of mobile geo-fencing targeting, based on consumers' real-time mobility behavior and firm's spatial differentiation. Two unique characteristics of mobile geo-fencing targeting are featured. First, consumers could move across different locations to maximize their total utilities. Second, firms' locations are not permanent, i.e., the relative position between consumers and firms is flexible. Our paper complements Chen et al. (2017) by studying mobile geo-fencing targeting with a different spatial structure, and new insights are obtained about the impact of price discriminationthe on firm's mobile targeting strategies and profits.

5 - Pre-Order Competition under Asymmetric Consumer Preference

Xuhan Tian, Hong Kong University of Science and Technology, Hong Kong, Hong Kong, xtianab@connect.ust.hk, Xiangtong Qi

This paper studies the pre-sale competition between two sellers offering horizontally differentiated products on an e-commerce platform. We consider a two-period model where consumers preference is realized in the second period and is asymmetrically distributed on a unit hoteling line. The pre-sale policy allows consumers to get a discounted price by paying a non-refundable deposit in the first period. We found that the less popular seller is more likely to operate the pre-sale strategy, which in some cases mitigates the competitive advantage of the other one. Besides, we proved the existence of some asymmetric equilibrium, where only one seller joins the pre-sale.

6 - Buy-One-Get-One Promotions in a Two-Echelon Supply Chain

Jing Zhou, Associate Professor, University of North Carolina-Charlotte, Charlotte, NC, United States, jzhou7@uncc.edu, Yuefeng Li, Moutaz J. Khouja, Jingming Pan

With "buy-one-get-one" (BOGO) promotions, the first unit of the product is sold for regular price and if a consumer buys a second unit, then it is discounted by some percentage. We analyze the working of BOGO promotions in a manufacturer-retailer supply chain. We find that for some type of consumer goods, with or without consumers stockpiling, a BOGO promotion always outperforms the commonly used price reduction promotion. We also find that the retailer's share of the supply chain profits is largest under BOGO while consumer surplus is smaller with BOGO than with price reduction promotion. When consumers are time-inconsistent, a price reduction promotion may outperform a BOGO promotion.

■ TE77

S- Fremont

Scheduling V

Contributed Session

Chair: Juan-Carlos Ferrer, Pontificia Universidad Catolica de Chile, Santiago, Chile

1 - Determining the Emergency Facility Location for Hazardous Materials via the Shapley Value

Ginger Yi Ke, Memorial University of Newfoundland, St. John's, NL, Canada, gke@mun.ca, Xun-Feng Hu

The consequence of possible incidents caused by the storage and transportation of hazardous materials may be catastrophic due to the harmful nature of the goods. To effectively mitigate such risks, an analytical approach rooted in the transferable utility cooperative game theory is proposed to find appropriate locations of emergency facilities, following a novel risk utility assessment method based on the response time. A small network example is studied to reveal the cooperative relationships among various facility locations and their corresponding marginal contributions to the overall performance of the emergency logistics system.

2 - Cooperative Games of Parallel Machine Scheduling Problems

Shoshana Anily, Professor, Tel Aviv University, Tel Aviv, Israel, anily@tauex.tau.ac.il, Tzvi Alon

In today's competitive market, firms have to supply goods to consumers under deadlines and penalties. In order to keep the schedule, and improve the operational efficiency, collaborations among manufacturing units of partners in a supply chain, are formed. The stability of such collaborations depends on the cost sharing principles agreed upon in the partnership contract. In this talk, the theory of cooperative games is used to design principles for core cost allocation schemes that can help maintain the stability of collaborations in various off-line Parallel Machine Scheduling (PMS) settings, under a few common cost functions, as e.g., the minimum makespan and the minimum sum of completion times.

3 - Service Point Worker Scheduling under Forecasting Demand for an Express Company

Qianru Ge, SF Technology, Shenzhen, China, geqianru9@hotmail.com

Labor cost accounts for a large proportion of the operating cost of the distribution network in express companies. This paper describes a model formulation for the service point worker scheduling problem in S.F. Express company. In this model, we first generate a monthly schedule that determines which shifts to use among all possible shifts, then a daily schedule is generated with the number of workers that are responsible for each shift in the monthly schedule. Moreover, this model also incorporates the prediction error of the forecasting demand by adding redundant workers in certain shifts according to an algorithm.

4 - Efficient Multi Break Shift Scheduling for Full Time Employees

Juan-Carlos Ferrer, Professor of Operations Management, Pontificia Universidad Catolica de Chile, Santiago, Chile, jferrer@ing.puc.cl, Esteban Alvarez, Juan-Carlos Muñoz, Cesar Henao

A shift scheduling methodology is presented to assign shifts with multiple breaks for providing flexibility to service companies and thus improve staff demand coverage. The approach is built around four modules that implement a sequential iterative process to solve the problem. A test case, using different daily demand profiles, generated results showing that the coverage obtained by the methodology under each profile was within one percent of the maximum attainable, despite assigning only one additional break to the mandatory lunch break period.

■ TE78

S- Greenwood

Data Envelopment Analysis III

Contributed Session

Chair: Gerd J Hahn, German Graduate School of Management and Law, Bildungscampus 2, Heilbronn, 74076, Germany

1 - Using an Extended Heterogeneous Game Cross-efficiency Model to Improve Performance of Community Health Service Institutions: A Case Study

Yuwei Hu, the First Affiliated Hospital of Anhui Medical University, Hefei, China, Xiang Ji

Community health service institutions show obvious heterogeneity in their operations. We propose an extended heterogeneous game cross-efficiency model via incorporating the advanced heterogeneous DEA techniques into the classical game cross-efficiency model. The proposed model is then applied into a real case study of community health service institutions in Hefei, China.

2 - Performance Evaluation of Healthcare System

Babak D. Rouyendegh, AYBU, Ankara, Turkey, babek.erdebilli2015@gmail.com

Performance evaluation of health care system Abstract This paper aims to evaluation the performance of Health care system in Ankara during the period of the 2016-2017 by using the combination of Intuitionistic Fuzzy TOPSIS and DEA. This paper demonstrates the utilization of the proposed methodology to solve the real life problem of healthcare management, DEA-IFTOPSIS methodology provides an opportunity to make the most suitable decision thought the value of the weights calculated by the data. Keywords Data envelopment analysis (DEA), Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS), Healthcare

3 - Drum-Buffer-Rope in an Engineering-to-Order System: An Analysis of an Aerospace Manufacturer Using Data Envelopment Analysis (DEA)

Daniel P. Lacerda, Universidade do Vale do Rio dos Sinos, São Leopoldo, Brazil, dlacerda@unisinos.br, Eduardo S. Telles, Maria I. Morandi, Ricardo A. Cassel

Increased productivity and efficiency in industries with engineering-to-order (ETOs) production systems have attracted growing interest. The application of the Drum-Buffer-Rope (DBR) of Theory of Constraints is considered an alternative to traditional improvement programs. This study aims to analyze the effects of implementing DBR on the efficiency of three ETO production lines of an aerospace manufacturer. The effects were evaluated longitudinally through a case study using Data Envelopment Analysis, Wilcoxon test and Analysis of Variance. The results show that the DBR implantation resulted in an increase of up to 19% efficiency, helped the prioritization and reduced lead times.

4 - Supply Chain Performance and Industry Sector Competitiveness: A Financial Market Perspective

Gerd J. Hahn, German Graduate School of Management and Law, Heilbronn, Germany, Marcus Brandenburg, Jochen Becker

Financial performance and analysis of value driver performance in supply chains (SC) is mostly studied using accounting data. In this paper, we use data from financial markets to investigate the impact of distinct value drivers on SC performance. Performance within and across several sectors is compared.

■ TE79

S- Issaquah A

Energy II

Contributed Session

Chair: Zhetao Chen, Rutgers University, South Plainfield, NJ, 07080, United States

1 - Scenario Selection for Iterative Stochastic Transmission Expansion Planning

Faezeh Akhavizadegan, Iowa State University, Ames, IA, United States, Faezeh.akhavizadegan@gmail.com, Lizhi Wang

Reliable transmission expansion planning is a critical part of a power system development due to existing numerous sources of uncertainty. We develop a new approach to selecting a small number of high-quality scenarios as representative of all scenarios. A bilevel optimization model was used to generate reasonable scenarios and regression model was used to estimate social welfare of scenarios to select high-quality scenarios. The US Eastern and Western Interconnections power system was used as the case study to select ten high-quality out of one million scenarios for two transmission plans.

2 - The Impact of Transportation Electrification on Power System Planning and Operation

Jonghwan Kwon, Argonne National Laboratory, Lemont, IL, United States, kwonj@anl.gov, Omer Verbas, Aymeric Rousseau, Zhi Zhou

The electricity industry is facing a rapid deployment of electric vehicles due to technological advances, cost reductions, and a desire for transportation electrification. This study will present the impact of the increased electricity demand from the transportation sector on power system planning and operations in both transmission and distribution system. This study will introduce an open-loop modeling framework that links the power system simulation tool, Argonne Least Cost Electricity Analysis Framework (ALEAF), and the transportation system modeling tool, POLARIS.

3 - Stochastic Transmission Expansion Planning: Approximating the Annual AC Operating Cost with the DC Subproblem

Jesse Bukenberger, Penn State, State College, PA, United States, jbukenbe@gmail.com, Mort David Webster

The nonlinear AC Optimal Power Flow (OPF) formulation has been too intractable to incorporate into transmission planning studies of a meaningful size and the linear DC OPF has been widely used instead, but accuracy improvements would result in large annual savings. We present a method for approximating the annual AC operating cost of a transmission plan from a sample of DC subproblems. The method uses AC OPF simulations from several feasible transmission plans and draws on multivariate statistics to relate the DC subproblem to the annual AC cost. Optimizations using this approximation scheme have better convergence properties than the AC model and produce better solutions than the DC model alone.

4 - A Lattice Method for Jump-diffusion Process Applied to Transmission Expansion Investments under Demand and Distributed Generation Uncertainties

Fikri Kucuksayacigil, Principal Financial Group, Des Moines, IA, United States

Decision makers of generation units and transmission networks do not often cooperate, which creates severe uncertainties for both. The growth of demand for electricity and installation or removal of distributed generation (DG) are among uncertainties encountered by transmission network owners. Expansion decisions for transmission lines should be strategically made, because installations of DGs may create a stranded cost for transmission owners. In this study, we propose a real options framework that quantifies the values of transmission networks and investments under demand and DG uncertainties. The proposed framework is demonstrated on a realistic transmission network.

5 - Resilience-based Design of a Microgrid System with Optimal Placement of Distributed Generators under Random Transmission Line Failures

Zhetao Chen, Rutgers University, Piscataway, NJ, United States, Zhimin Xi

This paper proposes a systematic framework for reliability and resilience quantification and design optimization for microgrid system considering random transmission line failures. Uncertainties of the system-level performance of interest, such as power recoverability and transmission efficiency, are quantified by Monte Carlo simulation (MCS) based on the power flow analysis. Given design constraints such as the minimum reliability requirements for the power factor and recoverability, optimal placement of distributed generators can be eventually obtained through the optimization. The proposed framework is demonstrated through a 12-bus power system.

■ TE80

S- Issaquah B

Joint Session ICS/ENRE-Electricity: Power Systems Planning

Sponsored: Computing

Sponsored Session

Chair: Cheng Guo, University of Toronto, Toronto, ON, M5T 1K5, Canada

1 - Incentive Compatibility for Power System Planning

Cheng Guo, University of Toronto, 204-222 Elm Street, Toronto, ON, M5T 1K5, Canada, cguo@mie.utoronto.ca, Merve Bodur

Power systems capacity expansion models have traditionally taken a centralized planner's perspective to find cost-optimal generation capacity to reliably meet load. Unfortunately, such models do not ensure individual generators are adequately remunerated. We present an expansion model that determines optimal generation/storage capacity investment decisions, while ensuring individual units achieve profitability.

2 - Breaking Temporal Correlations in Energy Storage Operation

Bolun Xu, Postdoc, MIT, Cambridge, MA, United States, xubolun@mit.edu, Audun Botterud, Magnus Korpas, Francis O'Sullivan

This talk introduces a dual decomposition method for the fast solution of multi-period energy storage control problems. The proposed method solves deterministic single storage control problems to optimal within milliseconds in all application scenarios regardless of the look-ahead horizon, offering significant improves compared to commercial optimization solvers. The talk will also introduce our current effort of applying this algorithm in optimizing multiple storage operations, and on incorporating uncertainties.

3 - Distribution Systems Hardening Against Natural Disasters

Arindam K. Das, Eastern Washington University, Seattle, WA, United States, adas@ewu.edu, Yushi Tan, Payman Arabshahi, Daniel Kirschen

Distribution networks are often crippled by catastrophic damage following a natural disaster. A suitably hardened system can significantly improve the performance of post-disaster restoration operations. We formulate a two-stage stochastic problem, where the inner operational problem addresses the proper scheduling of post-disaster repairs and the outer problem chooses the network components to harden. We propose a deterministic single crew approximation with two solution methods, an MILP formulation and a heuristic approach. Computational evidence on various IEEE test feeders illustrates that the heuristic approach provides near-optimal hardening solutions efficiently.

4 - Variability Constraints in Capacity Expansion Models: A Data-driven Approach

Mehrdad Pirnia, University of Waterloo, Waterloo, ON, N2L3G1, Canada, mpirnia@uwaterloo.ca, John David Fuller, Hassan Shavandi

We present a data-driven approach to include temporal operational constraints in a long-term electric capacity expansion plan, by incorporating variation constraints . The generation variation limits are estimated from historical data on maximum rates of change of each generation type. The proposed model is linear and therefore its execution time is incredibly fast. We discuss that although the results of this data-driven approach is not as accurate as a detailed mixed (nonlinear) integer capacity expansion model, it is plausible enough for analysts to consider rapid changes in demand. We illustrate the performance of the proposed model using data from Ontario's electricity market.

5 - Predictive Online Convex Optimization for Demand Response

Antoine Lesage-Landry, University of Toronto, Toronto, ON, Canada, Iman Shames, Joshua Adam Taylor

We incorporate side information in the form of the estimated value of future gradients in online convex optimization (OCO). This is motivated by demand response in power systems, where forecasts about the next rounds, e.g., the weather or the load patterns, can be used to improve on predictions made with only past observations. We introduce an additional predictive step that follows the standard OCO step and yields strict improvement over the latter when certain sufficient conditions are met. We provide a sublinear regret bound for all our algorithms. We apply our framework to demand response and demonstrates its superior performance to a standard OCO algorithm in regulation and curtailment settings.

■ TE81

S- Kirkland

Underground Mine Planning

Sponsored: Energy, Natural Res & the Environment/Natural Resources Mining

Sponsored Session

Chair: Alexandra M Newman, Colorado School of Mines, Golden, CO, 80401, United States

1 - Optimizing underground Mine Design with Method-Dependent Precedences

Pete Nesbitt, MS, Colorado School of Mines, Golden, CO, 80401, United States, Levente Sipeki, Alexandra M. Newman

Large underground hard rock mines are complex industrial projects by which success depends on intelligent design and detailed scheduling. We present an integer programming-based procedure for designing a mine consisting of two extraction methods in order to maximize profitability via its corresponding production schedules over the life of the mine. Solutions determine (i) by which methods an area of the mine is extracted and (ii) the time at which each activity takes place. We solve large-scale problems in a matter of hours; current industry practices require a month per solution, result in 35% less profit and, based on solution time, preclude strategic sensitivity analysis.

2 - Underground Production Scheduling with Ventilation

Oluwaseun Ogunmodede, MS, Colorado School of Mines, Golden, CO, 80401, United States

Mine production scheduling determines when, if ever, notional three dimensional blocks of ore should be extracted. The accumulation of heat in the tunnels where operators are extracting ore is a major consideration when designing a ventilation system. The production scheduling and ventilation decisions are not made in concert. Heat limitations from activities are largely ignored. Our model maximizes net present value subject to constraints on precedence, and mill and extraction capacities with the consideration of heat. The model produces more realistic schedules that could increase revenue by lowering ventilation costs for the mine.

3 - Short and Medium Term Planning in Underground Mines

Michel Gamache, Polytechnique Montreal, Montreal, QC, H3C 3A7, Canada, michel.gamache@polymtl.ca, Louis-Pierre Campeau

This presentation proposes linear programming and constraint programming models to solve the problem of short- and medium-term planning in underground mines. A comparison of the results obtained by the two models is carried out. Adapting these methods to solve real-time scheduling problems will also be discussed.

4 - Implementation of an Optimization Model for Sample Test Scheduling, the Case of a Metallurgical Laboratory in Antofagasta, Chile.

Pablo Orquera, Universidad Catolica del Norte, Antofagasta, Chile, pog005@alumnos.ucn.cl, Hernan Caceres

In the mining industry, quality control is essential. Quality controls are carried out by metallurgical laboratories that are responsible for taking samples of the mine processes and reporting their results promptly; the mine decision making depends on these results. This study aims to solve the problem of sample test scheduling in a metallurgical laboratory in Antofagasta, Chile. In our work, we study a multi-product and multi-stage problem, where several machines work in parallel depending on the type of sample being tested. We developed a MILP to determine the optimal sequence of the works. Heuristics and numerical tests will be presented for a real-world case study.

■ TE82

S- Leschi

Policy-Enabling Models for the Power Sector

Sponsored: Energy, Natural Res & the Environment/Environment & Sustainability

Sponsored Session

Chair: Afzal Siddiqui, University College London, London, WC1E 6BT, United Kingdom

1 - Multi-objective Infrastructure Investment under Uncertainty: Reconciling Private and Public Incentives.

Maria Lavrutich, Norwegian University of Science and Technology, Warandelaan 2, Trondheim, 5037AB, Norway, maria.lavrutich@ntnu.no, Verena Hagspiel, Afzal Siddiqui

We study optimal infrastructure investment decisions of a social planner (SP) that anticipates capacity investment of a private company (PC) in a market characterized by uncertain demand. The model captures the investment decisions of the SP and PC and accounts for the conflicting objectives and game-theoretic interactions of the distinct agents. Taking an option-based approach allows us to study the effect of uncertainty on the investment decisions and to take the agents' discretion over investment timing as well as size into account. We show if and how the SP can align the decision of the PC with the social optimum by exploiting the dependence of the PC's capacity on the SP's infrastructure design.

2 - A New Approach for Performing and Measuring the Quality of Data-aggregation Techniques in Power Systems Planning

Fabricio Oliveira, Assistant Professor, Aalto University, Espoo, Finland, fabricio.oliveira@aalto.fi, Lucas Condeixa, Afzal Siddiqui

Data aggregation (DA) is a key feature in modeling real-world energy systems. Considering existent DA techniques in long-term power systems models, we present two methodological contributions: the use of a statistically consistent metric to evaluate different DA algorithms and a novel DA method that maintains the chronological information. Results indicate improvements in the implementation of large-scale capacity expansion models in power systems using low temporal resolution. The analysis can be especially relevant for modeling systems with increasing amounts of renewable energy production.

3 - Green Electricity Investments Environmental Target and the Optimal Subsidy

Verena Hagspiel, Norwegian University of Science and Technology, Alfred Getz' vei 3, Trondheim, 7491, Norway, verena.hagspiel@ntnu.no

We investigate the optimal investment decision in renewables under market demand uncertainty, in the context of the Italian strategy for renewable deployment under the EU policy. The firm has to decide about the time and size of the investment. We find that a higher subsidy level induces the firm to invest earlier with a smaller investment capacity. This implies that a given environmental target cannot be reached by a too high (too low) subsidy level since this will cause the investment level to be too low (too late). There exists an optimal subsidy level to reach the environmental target. We propose a heuristic for policy makers to determine a subsidy level to reach the environmental target level in time.

4 - Can the European Intraday Market Be Designed as a Congestion Management Tool?

Mette Bjorndal, NHH Norwegian School of Economics, Helleveien, Bergen, 5045, Norway, mette.bjorndal@nhh.no, Somayeh Rahimi Alangi, Endre Bjorndal

With the large-scale penetration of intermittent generation resources in Europe, intraday markets have become more important. Since both day-ahead and intraday markets are based on zonal pricing, where the physical characteristics of the transmission networks are not fully taken into account, large amounts of unscheduled flows make it di cult for the networks to be in balance close to the delivery time. In this paper, we suggest a new design for the European intraday market, based on a coordinated multilateral trade approach. This approach lets us capture more of the benefits of the nodal pricing method, while it is compatible with the European electricity market structure.

■ TE84

S- Ravenna A

Data-driven Optimization in Energy Systems

Sponsored: Energy, Natural Res & the Environment/Energy

Sponsored Session

Chair: Spyros Chatzivasileiadis, Technical University of Denmark, Lyngby, 2800, Denmark

1 - Verification of Neural Network Properties for Power System Optimization

Andreas Venzke, Technical University of Denmark, Lyngby, 2900, Denmark, Spyros Chatzivasileiadis

Neural networks have been applied successfully to highly complex classification tasks including the security assessment of power systems. Current studies in power systems, however, use neural networks as black-box tools which presents a major obstacle towards their application in practice. To obtain provable performance guarantees, we verify target properties of neural networks used for power system optimization. To this end, we formulate the verification problem as a mixed-integer linear program. We verify properties of a security classifier that is then incorporated as a power system optimization constraint for an illustrative example and demonstrate the scalability for a 162 bus system.

2 - Learning-based Optimization of Power Grids

Emiliano Dall'Anese, University of Colorado Boulder, Boulder, CO, United States

We consider a time-varying optimization problem associated with a power system, with an objective that comprises a known time-varying cost and an unknown function modeling user's satisfaction. Gaussian processes (GP) are leveraged to learn the unknown cost function from noisy functional evaluation. We then advocates time-varying optimization tools to design an online algorithm that exhibits tracking of the oracle-based optimal trajectory within an error ball, while learning the user's function with no-regret. The algorithmic steps are inexact to account for possible limited computational budgets or real-time implementation considerations. Joint work with Andrea Simonetto, IBM Ireland.

3 - The Value of Including Unimodality Information in Distributionally Robust Optimal Power Flow

Bowen Li, Argonne National Laboratory, Lemont, IL, 60439, United States, bowen.li@anl.gov, Ruiwei Jiang, Johanna Mathieu

We assess the value of using both moment and unimodality information, which shrinks the ambiguity set and reduces conservatism, in distributionally robust OPF problems. Exact reformulations, approximations, and efficient solving techniques from previous work are compared on large scale systems with high uncertainty penetration. We also develop an optimal parameter selection approach that searches for an optimal approximation, significantly improving the computational time and solution quality. Results show that including unimodality information reduces solution conservatism without significantly degrading reliability.

4 - Optimal Adaptive Linearizations of the AC Power Flow Equations

Daniel K. Molzahn, Georgia Institute of Technology, Atlanta, GA, 60605, United States, molzahn@gatech.edu, Sidhant Misra, Tillmann Mühlpfordt, Bowen Li

The power flow equations relate the voltages and power injections in an electric power system. The nonlinearity of these equations results in algorithmic and theoretical challenges, including non-convex feasible spaces. Accordingly, many practical approaches for solving power system optimization and control problems employ linearizations of the power flow equations. This presentation describes a method for computing linearizations that are adaptive (tailored to a specific system and operating range of interest) and optimal (minimize a metric for the linearization error relative to the nonlinear AC power flow equations).

5 - D

istributionally Robust Data-enabled Predictive Control

Jeremy Coulson, ETH Zürich, Zürich, Switzerland

We study a data-enabled predictive control (DeePC) algorithm applied to unknown stochastic linear time-invariant systems. The algorithm uses noise-corrupted input/output data to predict future trajectories and compute optimal control policies. To robustify against uncertain data, the control policies are computed to minimize a worst-case expectation of a given objective function. Using techniques from distributionally robust optimization, we prove that for certain objective functions, the worst-case optimization problem coincides with a regularized algorithm. Probabilistic guarantees for its performance are provided. We illustrate the results on a grid-connected power converter.

6 - Chance-constrained AC Optimal Power Flow – A Polynomial Chaos Approach

Line A. Roald, Univeristy of Wisconsin - Madison, Madison, WI, 87544, United States, roald@wisc.edu, Tillmann Mühlpfort, Timm Faulwasser, Veit Hagenmeyer, Sidhant Misra

Chance-constrained optimal power flow, which allows us to limit the probability of constraint violations, has gained interest as a method to manage power systems uncertainty. Here, we propose polynomial chaos expansion as a method to formulate a tractable chance-constrained optimal power flow which explicitly considers the full nonlinear AC power flow equations. Beyond handling the non-linear, non-convex AC power flow constraints, polynomial chaos allows for a more detailed and flexible description of the system response to uncertainty. Two case studies highlight the efficacy of the method, with a focus on satisfaction of the AC power flow equations and on the accurate uncertainty propagation.

■ TE85

S- Ravenna B

Innovative Approaches to Integrated Multisector Modeling

Sponsored: Energy, Natural Res & the Environment/Energy

Sponsored Session

Chair: Stuart Cohen, National Renewable Energy Laboratory, Golden, CO, 80401, United States

1 - Modeling Opportunities for Coordinated Electric-water Utility Operations

Clayton Barrows, NREL, Golden, CO, 80401, United States

Water infrastructure system operations can create significant electrical energy consumption. Additionally, many water delivery systems are designed with excess pumping and storage capacity that present opportunities to shift pumping schedules and adjust electrical demand patterns. This research explores various levels of electric-water utility coordination by optimizing both water and power system schedules.

2 - Capturing Energy-water-Economy Interactions in an Integrated Modeling Framework: The Economic Impacts of Water Shortages on the Western Power Grid

Mort Webster, Pennsylvania State University, University Park, PA, United States, Karen Fisher-Vanden

The interactions between energy, water, and land systems are poorly understood, yet have important implications for food security, reliability of electric power supply, demographic patterns, and the resilience of communities and critical infrastructure. Doing this type of work requires working on multidisciplinary teams and coupling a variety of tools including statistical tools, data products, and computational models. In this paper, we present our initial results from coupling a water balance model, power system model, and a socioeconomic model to assess the impacts of a severe water shortage in the western U.S. on the power system.

3 - Spine: An Open-source and Flexible Energy-system Model Generator

Kris Poncelet, PhD, KU Leuven, Leuven, Belgium, kris.poncelet@kuleuven.be

Due to the increasing complexity of the energy system, there is a growing need to integrate or link models covering different energy sectors or time frames. Currently, the vast majority of models have been developed with a specific purpose in mind (e.g., investment planning, unit commitment, simulation of gas flows, etc.). Within the H2020 Spine project, the goal is to develop an open-source and flexible energy system model generator that is designed from the offset to perform these different functions and facilitate linking of models. In this regard, key features of Spine are the model's generically formulated equations and the interface enabling a direct link between the data and the source code.

4 - A Co-Simulation Framework to Study Future Energy-Economy Interactions

Stuart Cohen, Electricity System Analyst, National Renewable Energy Laboratory, Golden, CO, 80401, United States, stuart.cohen@nrel.gov

Energy-economy interactions are often studied using top-down integrated assessment or economy models that have broad scope but lack the resolution and process detail to consider complex emerging trends across the energy sector. This presentation describes an approach to maintain both detail and scope by linking NREL's highly resolved models of the electricity, transportation, and buildings sectors with a MIT's USREP computable general equilibrium model of the U.S. economy. We will discuss strategies for linking across disparate models along with preliminary results describing the economy-wide impacts of future energy technology innovation.

■ TE86

S- Ravenna C

Joint Session Adv Manufacturing/Practice Curated: Modeling and Control of Smart Manufacturing Systems II

Emerging Topic: Advanced Manufacturing

Emerging Topic Session

Chair: Feng Ju, Arizona State University, Tempe, AZ, 85281, United States

1 - Unified New Product Introduction Model with Learning and Congestion Effects

Atchyuta Bharadwaj Manda, North Carolina State University, Raleigh, NC, United States, amanda@ncsu.edu, Reha Uzsoy

The adverse impact of new product introductions on the performance of semiconductor wafer fabrication facilities is widely acknowledged. We develop a deterministic new product introduction production planning model that captures the initial drop in efficiency and the learning effects that follow. The model captures learning by gaining production experience and learning through deliberate experimentation. We incorporate the congestion effects and capture the effect of the product introduction on the output of the fab as a whole. We develop a solution methodology to solve the resulting nonlinear non-convex formulation using nonlinear programming and genetic algorithms.

2 - Semi-supervised Constrained Hidden Markov Model Using Multiple Sensors for Remaining Useful Life Prediction and Optimal Predictive Maintenance

Yunyi Kang, Arizona State University, Tempe, AZ, 85281, United States, ykang37@asu.edu, Feng Ju

In this work, we propose a framework to demonstrate the optimal preventative maintenance decision making using multiple-sensor data. A semi-supervised left-to-right constrained Hidden Markov Model (HMM) model is used to learn the hidden states, which is the first to simultaneously address the challenges of semi-supervised setting, left-to-right constraint, and monotonicity constraints. The a Partial Observable Markov Decision Process (POMDP) is built up to demonstrate how the hidden states can be effectively used for optimal preventative maintenance decision making. We apply this technique to the data, such as the NASA Engine data, and demonstrate the effectiveness of the proposed method.

3 - Prognostics for Ion Mill Etching Process Through Deep Learning Multimodal Data Fusion

Xiaoning Jin, Assistant Professor, Northeastern University, Boston, MA, 02115, United States, xi.jin@northeastern.edu, Anqi He, Xiaomeng Peng

Ion Mill Etching (IME) is an advanced process technology that uses ion-beam sources to remove materials by atomic sandblasting in order to reveal a specific pattern on the substrate. The high-precision capability requires stringent process monitoring and control of the flowcool system. This study focuses on a multi-sensor data analytics to monitoring the IME process condition-enabling diagnostics and prediction of three main failure mechanisms of the IME flowcool system. A generalizable framework of engineering-based data-driven failure diagnostics and prediction is developed using random forest-based classification and a Deep Long Short-Term Memory based failure prediction.

4 - Design and Operation of Individualized Single-use Systems: Car-t Cell Therapy

Gaurav Sharma, Arizona State University, Tempe, AZ, 85281, United States, gsharm16@asu.edu, Mohammad Hekmatnejad, Giulia Pedrielli, Georgios Fainekos

The success of genetically-modified T-cells in treating hematological malignancies has accelerated the registration timeline for CAR-T cell therapy. The individualized nature limits inventory and creates a high risk of product loss due to supply chain failure. The sector needs a new manufacturing paradigm capable of quickly responding to single-use demands while considering complex system dynamics. Our research formulates the problem of CAR-T manufacturing design and control, understanding the performance of centralized and decentralized single-use systems for large scale production of personalized therapies.

■ TE87

S- Madrona

Health Care, Public Health II

Contributed Session

Chair: Mehrad Bastani, Stanford University, Mountain View, CA, 94040, United States

1 - Developing a Cox Proportional Hazards Model with Time-dependent Covariates to Evaluate the Risk of Acute Kidney Injury

Farnaz Babaie Sarijaloo, PhD student, University of Florida, Gainesville, FL, United States, farnazbs@ufl.edu, Shounak Datta, Ying-Chih Peng, Matthew Ruppert, Subhash Nerella, Arsenios Tsokas, Tezcan Ozrazgat-Baslanti, Parisa Rishidi, Panayote (Panos) M. Pardalos, Azra Bihorac

Acute Kidney Injury (AKI) is a serious complication in patients with a rising incidence and high mortality rate. Most of the models for AKI risk prediction are developed for patients with a cardiac surgery and analyzed their risk after a surgery. Accurate AKI severity assessments would help identify patients in need of life-saving interventions prior to the occurrence of an unexpected AKI. In this study, a cohort of 15239 patients admitted at University of Florida Health from 2014 to 2016 have been examined. The main purpose of this study is to develop a survival model to determine time to AKI for patients in a daily basis. We used survival and statistical analysis to model the time to AKI.

2 - An Innovative Tumor Response Model for Personalized Breast Cancer Treatment

Melike Hazal Can, Northeastern University, Boston, MA, United States, Abe Zeid, Sagar Kamarthi, Stephen O. Agboola, Kamal Jethwani, Ramya S. Palacholla

Breast cancer is the most common cancer diagnosed among women in the US and worldwide. Even though there has been a dramatic increase in our knowledge of cancer on multiple scales leading to a host of potential drug targets and subsequent clinical trials, outcomes for many cancers have not improved significantly. A tailored treatment approach can help avoid overtreatment in breast cancer patients. In this study, we aim to develop a novel data-driven model that considers individual variability in baseline patient characteristics and tumor characteristics to predict the probability of a complete pathological response in breast cancer patients that is a proxy for improved survival and better outcomes.

3 - Optimization of Diagnostic Follow-ups for Effective Lung Cancer Screening

Mehrad Bastani, Postdoctoral Scholar, Stanford University, Stanford, CA, United States, bastani@stanford.edu, Iakovos Toumazis, Julien Hedou, Ann Leung, Sylvia Plevritis

Lung cancer screening with low-dose computed tomography (LDCT) has been recommended, based primarily on the results of the NLST (National Lung Screening Trial). In response to the high rates of false-positive findings observed in NLST, the American College of Radiology recently released Lung-RADS, a classification system for LDCT lung cancer screening. Diagnostic follow-ups recommended by Lung-RADS could be potentially modified to improve the effectiveness of LDCT. To this end, we propose a population-level simulation-based optimization model to maximize life-year gained and mortality reduction.

■ TE88

S- Cedar A

Health Care, Modeling and Optimization XI

Contributed Session

Chair: Eric Enkele Longomo, University of Portsmouth, Yorke Street, Southsea, Portsmouth, PO5 4EL, United Kingdom

1 - Evidence-based Comparison of Queuing and Discrete-event Simulation Models for Patient Flow Improvement

Farzane Asgari, Visdom, New York, NY, United States, cf@visdom.org, Sadegh Asgari

Queuing theory and discrete-event simulation have been extensively utilized to improve patient flow in healthcare systems. Using the patient flow data of an obstetric unit, we develop different simulation and queuing models and compare their results to assess their accuracy, strengths, and limitations. The results show that simulation models, compared to queuing models M/M/K and M/G/K, obtain more realistic estimations of performance metrics of patient flows if admissions are partially scheduled. However, queuing models M/M/K and M/G/K can be appropriate estimators for performance metrics if admissions are only unscheduled.

2 - Optimizing Nurse Schedules for a Community Health Centre Serving a Marginalized Population in Vancouver, Canada

Samantha Zimmerman, Simon Fraser University, Burnaby, BC, Canada, Alan Bi, Trevor Dallow, Krisztina Vasarhelyi, Cameron Bye, Latham Nicole, Andrew Day, David Hall, Tamon Stephen, Alexander R. Rutherford

We modeled a community health centre serving marginalized individuals, with complex clinical and psycho-social needs, who experience barriers to accessing healthcare. To improve service delivery, a mixed integer linear programming model was built to optimize nurse schedules. The model draws on appointment data to maximize patient-nurse contact time while maintaining coverage and hours. Key performance indicators for the optimized schedule were assessed using discrete event simulation. Without increasing staffing levels, optimization can increase patients seen by ten per week, remove gaps in coverage, and reduce the percentage of walk-in patients waiting over 90 minutes from 34% to 13%.

3 - Using Linear Program and Simulation to Optimize CRNA Regular and Call Shift to Accommodate Anesthesia Care Needs

Luqing Lu, Senior Health Systems Engineer, Mayo Clinic, Scottsdale, AZ, United States

Certified Registered Nurse Anesthetists (CRNAs) are highly utilized resources in integrated hospitals. Although most of CRNA staffing needs happen between 0630 and 1700, emergency surgeries can occur past hour needing resources. We review the variation in number of CRNAs needed at different time of the day, the frequency of on-call staffs are called due to understaffing given current shift assignment and other factors to build a model. The model can be used by CRNA supervisors to determine shift schedule (starting time, duration, and number of staff per shift) to minimize staffing costs while maintaining call shifts at the industry-average level.

4 - Modeling Parallel and Sequential Random Delays in Capacity Adjustment of Supply-demand Systems

Sara Nourazari, California State University, Long Beach, Long Beach, CA, United States, sara.nourazari@csulb.edu

Closed-loop supply-demand models can be used to manage capacity adjustments in healthcare systems. However, these methodologies are traditionally organized around deterministic delays. When the delay is non-deterministic, in order to apply the tractable deterministic models, the mean of the probability distribution of delays is often used as a crude estimate. This work assesses the cost of over-simplifying delay distributions, proposes a methodology to holistically incorporate multiple probabilistic delays in the system, and optimizes systems parameters to assist in informed capacity management decision-making. Parallel, sequential, and mixture delays are modeled and analyzed.

5 - Keep Pushing or C-section? A Machine Learning Approach Using Optimal Trees

Daisy Zhuo, Interpretable AI, Cambridge, MA, United States, daisy@interpretable.ai, Dimitris Bertsimas, Jack W. Dunn, Jordan Levine, Alexis Gimovsky

In the delivery room, it highly time sensitive for a obstetrician to make an informed decision as the woman in labor is pushing whether and when to switch to a Cesarean section, as both involve risk of mother and child mortality and morbidity. Using data from Consortium of Safe Labor with 140,000 deliveries, we have developed a highly accurate machine learning model to predict the mode of delivery. The model is trained using Optimal Trees, a state-of-the-art algorithm that finds an interpretable decision tree with high predictability. We also present the mother and child risk over time within each cohort, providing guidance on optimal time of switching.

6 - Real-time Prediction of the Optimal Configuration of an Intelligent Gateline System Using Queueing Theory

Eric Enkele Longomo, Research Fellow in Applied Operational Research, University of Portsmouth, Portsmouth, United Kingdom, eric.longomo@port.ac.uk

This work develops and operationally demonstrates -using queuing theory and combinatorial optimisation, a gateline that is capable of automatically self-reconfiguring to maximise peak and average throughput and prevent train station overcrowding. The technology will identify flows of people within the station environment, and learn to predict crowds before they arrive at the gateline. The technology will allow each gate to be configured to be inflow or outflow to deliver reliability and capacity improvements and give the passengers the best experience possible

■ TE89

S- Cedar B

Quantitative Methods in Financial Engineering

Sponsored: Finance

Sponsored Session

Chair: Ning Cai, Hong Kong University of Science & Technology, Kowloon, Hong Kong, Hong Kong

Co-Chair: Li Lingfei, University of Hong Kong, Hong Kong, China

1 - Distributionally Robust Mean-Variance Portfolio Selection

Xunyu Zhou, Liu Family Professor of Financial Engineering, Columbia University, New York, NY, 10027, United States

We revisit Markowitz's mean-variance portfolio selection model by considering a distributionally robust version, where the region of distributional uncertainty is around the empirical measure and the discrepancy between probability measures is dictated by the so-called Wasserstein distance. We reduce this problem into an empirical variance minimization problem with an additional regularization term. Moreover, we extend recent inference methodology in order to select the size of the distributional uncertainty as well as the associated robust target return rate in a data-driven way.

2 - On the Equilibrium Strategies for Time-inconsistent Problems in Continuous Time

Zhaoli Jiang, Chinese University of Hong Kong, Shatin, N.T, Hong Kong, zljiang@se.cuhk.edu.hk

In a continuous-time setting, the notion of weak equilibria employed in the literature to study continuous-time time-inconsistent decision problems is not aligned with the standard definition of equilibria in the game theory. To address this issue, we propose two new notions of equilibrium strategies for time-inconsistent problems, named regular equilibria and strong equilibria. We derive sufficient conditions as well as necessary conditions for a strategy to be a regular equilibrium and to be a strong equilibrium. We exemplify that a regular equilibria may not be a strong equilibria and that a weak equilibria may not be a regular equilibria.

3 - Partially Egalitarian Portfolio Selection

Yiming Peng, Northwestern University, Evanston, IL, United States, ypeng@u.northwestern.edu, Vadim Linetsky

We develop a novel portfolio selection framework via machine learning.

4 - Conditional Monte Carlo Methods under Stochastic Volatility Models

Gianluca Fusai, City, University of London, London, United Kingdom, Riccardo Brignone, Kyriakou Ioannis

We develop conditional Monte Carlo methods for simulating the Heston, SABR, and OU stochastic volatility models. Sampling from these models represents a nontrivial longstanding problem and various solution have been attempted in the literature. Our method exploits the moments of the conditional integrated variance to develop accurate approximation methods. Besides the more standard case of path-independent derivatives, we show the applicability of our method to path-dependent options as well, such as barrier, lookback and hindsight options. Numerical experiments highlight the accuracy-runtime benefits of our proposed methodologies.

■ TE90

S- Redwood A

Joint Session MSOM/HC/Practice Curated: Healthcare Applications

Sponsored: Manufacturing & Service Oper. Mgmt/Healthcare Operations

Sponsored Session

Chair: Sandeep Rath, University of North Carolina at Chapel Hill - Kenan Flagler, NC, 27599, United States

1 - Staff Planning with Cost Estimation and Optimization

Sandeep Rath, University of North Carolina at Chapel Hill-Kenan Flagler, Chapel Hill, NC, 27599, United States, sandeep@unc.edu, Kumar Rajaram

We consider the staff planning problem of anesthesiologists which consists of determining how many anesthesiologists have to be on regular duty and on call each day. We model this problem as a two-stage integer stochastic dynamic program. We use data from the anesthesiologist staff planning at UCLA Ronald Reagan Medical Center to first estimate the inconvenience costs of on-call staffing. We use these estimated cost parameters in a two-stage integer stochastic dynamic programming model of staff planning. We develop a solution algorithm, and test the model with real data from the UCLA medical center.

2 - Optimal Dynamic Appointment Scheduling of Base and Surge Capacity: Early Follow-up for Congestive Heart Failure

Benjamin Grant, Kellogg School of Management, Evanston, IL, 60201, United States, Itai Gurvich, R. Kannan Mutharasan, Jan A. Van Mieghem

We study dynamic stochastic appointment scheduling when delaying appointments increases the risk of incurring costly failures, such as readmissions in health care. When near-term base appointment capacity is full, the scheduler faces a trade-off between delaying an appointment at the risk of costly failures versus the additional cost of scheduling the appointment sooner using surge capacity. We present sufficient conditions for the optimality of simple policies.

3 - The Interplay Between Online Reviews and Physician Demand: An Empirical Investigation

Yuqian Xu, University of Illinois at Urbana-Champaign, Champaign, IL, 61820, United States, Mor Armony, Anindya Ghose

Social media platforms for healthcare services are changing how patients choose physicians. The digitization of healthcare reviews has been providing additional information to patients when choosing their physicians. In this paper, we derive various service-quality proxies from online reviews and study the relationship between these quality proxies and physician demand. To do so, we study a unique data set from one of the leading appointment booking websites in the United States, that contains online physicians' appointments made over a five-month period, along with other online information.

4 - Tradeoffs in the Use of Cohort Matching to Estimate Causal Effects from Observational Data on the Use of an Online Healthcare Navigation Service.

Shishir Dash, PhD, Grand Rounds, San Francisco, CA, United States

We studied the use of various cohort matching tools to design an observational study of medical claims data to estimate the causal effect of using healthcare navigation platforms on medical spend. We explore tradeoffs in using methods such as propensity-scoring, distance and matching to account for the dependence of cohort-assignment on the covariate distributions, and present simulated and actual results.

■ TE91

S- Redwood B

Joint Session MSOM/HC/Practice Curated: Non-profit Logistics

Sponsored: Manufacturing & Service Oper. Mgmt/Healthcare Operations

Sponsored Session

Chair: Jonas Oddur Jonasson, MIT Sloan School of Management, Cambridge, MA, 02142, United States

1 - An Indirect Prioritization to Optimizing Sample Referral Networks for HIV Early Infant Diagnosis

Reut Noham, Northwestern University, Evanston, IL, United States, noham.reut@northwestern.edu, Michal Tzur, Dan Yamin

We developed a supply chain network-model for delivering HIV test samples between clinics-to-labs in Tanzania. Our model is used to minimize the expected number of infants who die from AIDS due to delays in the return of test results. We present an analytical framework to evaluate the distribution of the samples' waiting times at the testing labs, which we incorporated into the model. Our findings indicate that redesigning clinics-to-labs assignments, yielded an indirect prioritization of samples that are more likely than others to be positive. We demonstrate the applicability of our findings and its potential benefit to reduce mortality compared to the current assignment policy in Tanzania.

2 - Access to Safe Water: Operational Challenges of Water Filter Supply in Ethiopia

Chengcheng Zhai, Indiana University, Bloomington, IN, United States, zhaic@iu.edu, Alfonso Pedraza Martinez, Jorge Mejia, Kurt M. Bretthauer

More than 60 million Ethiopians lack access to safe water. Using daily data, we study an NGO that tackles this problem by distributing water filters in the country. The NGO faces challenges regarding manufacturing, storage and distribution of their product.

3 - Sample Transport Optimization

Emma L. Gibson, MIT, Cambridge, MA, 02142, United States, Jonas Oddur Jonasson, Sarang Deo, Kara Palamountain, Mphatso Kachule

Sample transportation systems are an integral component of diagnostic networks in many developing countries, enabling physical transportation of samples (e.g., dried blood spots, plasma, or sputum samples) from health centers to medical laboratories. We have partnered with Riders For Health Malawi to improve the efficiency of their sample transport operations through data-driven analytics and optimization.

4 - Supply Chain Network Design Considering Investments that Drive Demand

Jarrod D. Goentzel, Massachusetts Institute of Technology, Cambridge, MA, 02139, United States, Tim Russell, Francisco Jauffred

Demand in supply chain network design is usually given and exogenous to optimization models that minimize cost. However, proximity to supply facilities may influence price and service sufficiently to affect customer behavior. In such cases, investment in network infrastructure may be more than offset by returns from serving more demand. We present a model developed for price- and time-sensitive commodities at a chemical company. We then consider application of this model for investment in non-profit health facilities to increase vaccine penetration.

■ TE96

S- Willow A

Data Mining IV

Contributed Session

Chair: Reza Alizadeh, The University of Oklahoma, Norman, OK, 73019-1022, United States

1 - Using Surrogate Modeling for Complex Systems Design

Reza Alizadeh, The University of Oklahoma, Norman, OK, United States, reza.alizadeh@ou.edu

Many decision-making problems include two levels of decision making, where one decision is nested within the other. these problems are known as bilevel decision-making problems and are computationally intensive. in this paper, we exploit a mapping of the bilevel problem which using that we relate the upper-level variables with the corresponding expense by iteratively approximating the exploited mapping function. This is an initial study with that we examine the idea on a small set of test problems.

2 - Community Detection Based on Graph Neural Network

Lee Chul Hee, Myongji University, Yongin-si, Korea, Republic of, Dohyun Kim

Communities in social networks are the dense subgroups of the nodes, which are tightly connected to each other within the group. Detecting communities is one of the importance tasks because it plays a key role in understanding the functionality of complex networks. Recently, many deep learning algorithms to detect communities in social networks have been studied due to their robust performance. In this paper, we propose a unified community detection method combined hidden feature extraction and clustering algorithms. The proposed method combines graph Auto-Encoder (GAE) and Deep Embedding Clustering (DEC) in social network.

3 - A Projection-based Framework for Prediction of Binary Labels for Links in Signed Networks

Mukul Gupta, Indian Institute of Management Indore, Indore, India, mukulg@iimidr.ac.in, Saurabh Kumar

The prediction of labels for links in a signed network where the links between nodes have a positive or negative sign is relatively less explored and very challenging problem. In this work, we consider the problem of binary label prediction for links in undirected and unweighted signed networks. We propose a novel projection-based framework that projects the network into positive-links and negative-links networks with unlabelled links and uses the concept of random-walk for prediction of binary labels for links. In this work, we demonstrate the viability and effectiveness of the proposed approach using a real-world network.

4 - A Novel Optimization Based Algorithm for Multi-Class Data Classification Problem

Fatih Rahim, Koç University, Istanbul, Turkey, Metin Turkay

Multi-class data classification is a supervised machine learning problem that involves assigning data to multiple groups. We present a novel MILP-based algorithm that splits each class's data set into subsets such that the subsets of different classes are linearly separable. At each iteration we form a subset of samples out of the set of unassigned samples by a MILP model that maximizes the cardinality of the new subset. The algorithm terminates when all the samples are assigned. We build classifiers based on the convex hulls of the subsets and the polyhedral regions for the testing phase. We conclude that our optimization based algorithm provides competitive results in terms of prediction accuracy.

5 - One-class Peeling for Anomaly Detection in High Dimensions

Waldyn Martinez, Miami University, Oxford, OH, United States, martinwg@miamioh.edu

Outlier detection is important for preprocessing data and/or for detecting anomalous observations. Numerous outlier detection methods have been proposed in the fields of statistics, machine learning, and data mining. These methods can be computationally infeasible for high dimensional data. In this paper we propose a flexible framework to detect multiple outliers that does not require covariance estimation, is well-suited to high-dimensional datasets with a high percentage of outliers, and is robust to parameter specification. We evaluate our framework using both synthetic and benchmark data sets, showing that it works well in high dimensions and performs better than benchmark methods.

6 - Partial Change Detection Using Homogeneity Tests

Maziar Kasaei Roodsari, Arizona State University, Tempe, AZ, United States, mkasaeir@asu.edu, George Runger

In this work, we address partial change detection. We refer to a change as partial when not all measurements within the sample are affected by the assignable cause. Nowadays, in statistical quality control, the subgroups can be much larger than they used to be and identifying a change in which only a subset of the instances are affected, would not be trivial. We investigate partial change detection using homogeneity tests under two scenarios for which the changed part of the data follows: 1. a Gaussian distribution, 2. an unspecified distribution. Through simulations, we show that the sample statistics based on likelihood ratio test can have higher power than the sample average.

■ TE97

S- Willow B

Supply Chain and Logistics

Contributed Session

Chair: David Fuessler, Friedrich-Schiller-University Jena

1 - Industry 4.0 Concepts to Improve Agroindustry Supply Chains

Alcides Santander-Mercado, Universidad del Norte, Barraquilla, Colombia, asantand@uninorte.edu.co, Maria A. Jubiz-Diaz, Juan C. Urueta-Urueta

This research focuses on the development of integrated solutions to improve the synchronization of supply chains on rural areas (palm oil industry in Colombia), where the uncertainty about the supporting infrastructure is high. The analysis is based on the implementation of industry 4.0 concepts to enhance their key performance indicators related to logistic processes. The implementation of RFID technologies as well as Business Process Modeling (BPM) and supply chain synchronization techniques, helped them to achieve better performance indicators and improve their competitiveness.

2 - New Switch Mechanism Design and GPU Parallel Computing Implementation for Large Scale VRP

Rui Yu, Senior Algorithm Engineer, Zhejiang Cainiao Supply Chain Management Co., Ltd., Hangzhou, China, geminikop@gmail.com, Haoyuan Hu

In this presentation, a switching mechanism is introduced to realize and control both exploration and exploitation in the evolutionary algorithm, to accelerate the discovery of good solutions for large-scale problems. The switching mechanism "guides" the algorithm to find better solutions more quickly. Moreover, we also introduce the GPU parallel computing implementation based on CUDA. Experimental results on Gehring and Homberger's benchmark show that this algorithm outperforms previous approaches and improves 71 best-known solutions out of 180 large-scale instances.

3 - Performance Evaluation for a New Compact Automated Vehicle Parking System with Double Storage Rings

Guangmei Wu, School of Information Management, Central China Normal University, Wuhan, China, Bipan Zou

Compact robotic parking system is a new system with higher storage utilization and rapid response to store and handle cars. This system has double storage rings, instead of one storage ring in old compact automated parking (CAP) system for storing cars in each tier, and each tier is equipped with inner rotating ring and tier-captive automated guided vehicle for horizontal transport.

4 - Trolley Line Picking: Storage Assignment and Order Sequencing to Increase Picking Performance

David Fuessler, Friedrich-Schiller-University Jena, Jena, Germany, david.fuessler@uni-jena.de, Nils Boysen, Konrad Stephan

In a trolley line picking system, unit loads of stock keeping units (SKUs) are positioned along a path passed by automated trolleys. Once a trolley reaches a requested SKU, it automatically stops, and an accompanying human picker puts the demanded items onto the trolley. After an order is completed the subsequent picking order is served. The performance of a trolley line system is mainly influenced by the picker's unproductive walking between SKUs during order processing and switching trolleys. It is investigated how the storage assignment of SKUs along the path and the order sequence influence picking performance.

Wednesday, 8:00AM - 9:30AM

■ WA01

CC- Room 201

Applied Business Analytics

Sponsored: Data Mining

Sponsored Session

Chair: Murtaza Nasir

1 - Predicting Patient No-shows via a Hybrid Business Analytics Methodology

Nichalin S. Summerfield, University of Massachusetts Lowell, OIS Department, One University Avenue, Lowell, MA, 01854, United States, Murtaza Nasir, Asil Oztekin, Ali Dag

Patients who fail to show up for an appointment (no-shows) are a major challenge for medical settings. They reduce revenues and in turn negatively affect overall healthcare quality. Understanding the reasons for no-shows and predicting them are key to developing a successful, proactive strategy in healthcare operations. In this study, we propose a data analytics framework to explore the underlying factors of noshows. We employ Support Vector Machines, Artificial Neural Networks, Decision Tree, Logistic Regression, and Random Forest to predict whether a patient is a noshow. Information fusion based sensitivity analysis is deployed to understand how such variables contribute to this prediction.

2 - Impact of Peer Influence on Product Adoption: Evidence from Video Game Platforms

Yang Li, Drexel University, Philadelphia, PA, United States, yl837@drexel.edu

We investigate how peer influence affects customers' product adoption behaviors in emerging video game platforms. Using data from the world's largest digital distribution platform for video games, we leverage the state-of-the-art recommender system algorithms and propose an innovative framework to identify social influence in the adoption of video games when a confounding homophily effect is present. The results show that peer influence has a positive impact on the adoption behaviors of platform users (i.e., a user tends to adopt a video game that has been purchased by his peer) and this impact will be overestimated if homophily was not properly accounted for.

3 - The Impact of an Augmented-Reality Game on Local Businesses: A Study of Pokemon Go on Restaurants

Vandith Pamuru Subramanya Rama

Upon release, Pokemon Go, an augmented-reality technology-based game, garnered tremendous interest in the public with an average of 20 million active daily users. Using online reviews of restaurants as a proxy for consumer engagement and perception, we study the impact of Pokemon Go, on local restaurants. We treat the release of Pokemon Go, as a natural experiment and study the post-release impact on the associated restaurants. Thereby, our research lays the foundations of how augmented-reality games affect consumer economic behavior. It also helps to build insights into the potential value of such associations for business owners and policymakers.

4 - Firm Automation and the Gender Gap in Human Capital Acquisition

Amanda Chuan, Michigan State University, East Lansing, MI, United States, chuan.amanda@gmail.com

Women now exceed but used to lag behind men in college enrollment. I use census data to show that the automation of the labor market from 1960-2000 contributed to the growth in female college enrollment over male college enrollment. Using a shift-share instrumental variable approach, I find that local labor markets which experienced greater automation experienced larger declines in the jobs that typically employed non-college women. The response was a significant rise in the enrollment rates of women, with no discernible change in the enrollment rates of men. Thus, the automation of the office appears to have contributed to the gender gap in college enrollment.

■ WA02

CC- Room 202

Big Data Analytics and Data-driven Decision making

Sponsored: Data Mining

Sponsored Session

Chair: Xiaochen Xian

Co-Chair: Xu Sun, University of Florida, University of Florida, Gainesville, FL, United States

1 - Value of Continuous Monitoring System in Recurrent Decision Scenarios

Xinyang Liu, University of Illinois at Urbana-Champaign, Urbana, IL, United States, Pingfeng Wang

Continuous monitoring systems have been applied to diversified systems for well-informed operations. Plenty research has devoted to system state prediction using the continuous data flow while engineering system owners still lack a systematic decision-making framework to maximize their benefits on adopting monitoring systems. This paper constructs such a decision-making framework, with which system owners can evaluate the operation cost change under specific operation modes. State-of-the-art system degradation models and maintenance policies have been reviewed. Finally, a battery asset management case study has been implemented to illustrate the efficiency of the framework.

2 - End-to-end Learning of Personalized Driver Behavior Models

Jundi Liu, University of Washington, Seattle, WA, United States, jundiliu@uw.edu, Ashis Banerjee

Modeling and forecasting driver behavior are crucial in developing efficient and comfortable driver assistant systems in automated vehicles. Short-term behavior has been well studied using high frequency video data. However, long-term behavior is closely related to driver's individual preference. For example, conservative drivers tend to maintain a larger gap between the front vehicle and decelerate earlier compared to aggressive drivers. In this study, we focus on learning personalized driver behavior models for different groups of drivers. Results show promising accuracy and individual difference in predicting driver behavior.

3 - Optimizing Movie Profits via Deep Learning-based Cast Recommendation

Michael T. Lash, Assistant Professor, University of Kansas, Lawrence, KS, 66045, United States, michael.lash@ku.edu, Kang Zhao, Nick Street

The average movie garners approximately $50 million in investment dollars, yet has only a 30% chance of producing a return on this investment. A major factor that contributes to the box office success of a movie is the cast, which can be represented as a network of co-staring individuals from which movie-centric, network-based measures can be derived and used to predict profitability. Therefore, in this work, we propose leveraging predictive models to elicit cast recommendations that optimize for movie profitability.

4 - Data-driven Size-based Scheduling in Queues

Xu Sun, University of Florida, University of Florida, Gainesville, FL, United States

Consider an M/GI/1 queue operating under a two-class nonpreemptive priority scheduling policy parameterized by a cut-off point p where customers with service requirement less than p get higher priority. The goal is to find the optimal cut-off value that minimizes the mean waiting time, but the underlying service-time distribution is not known. Instead, the only information available is a random, independent sample drawn from the service-time distribution. This study analyzes the sample average approximation approach for the problem and establishes performance guarantee.

■ WA03

CC- Room 203

Health Care, Strategy and Policy II

Contributed Session

Chair: Balaraman Rajan, California State University East Bay, Pleasanton, CA, 94588, United States

1 - Performance-based Reimbursements of Health Providers under Comorbidities

Stefan Feuerriegel, ETH Zurich, Zurich, Switzerland, sfeuerriegel@ethz.ch, Patrick Zöchbauer

Health care reimbursements in the US exceeded USD 3.7 trillion in 2018. However, these reimbursements to healthcare providers are variable if providers fail to achieve a pre-defined quality of care. Key to performance-based reimbursements is a quality measure of hospital performance that caters for the fact of providers serving different patient cohorts. Despite extensive research on performance measures, prior attempts neglect comorbidities, i.e., co-occurring patterns of secondary diseases. We introduce a novel statistical model based on deep learning in order to accommodate comorbidities. In fact, we find that this results in extensive annual misallocation of reimbursements.

2 - Proposing a Mobile-based Outpatient Healthcare Service Delivery Framework and Investigating the Acceptance from Outpatients' Perspective

Muhammad Adnan Zahid Chudhery, Assistant Researcher, School of Economics and Management, Tongji University, Shanghai, China, adnanch@mail.ustc.edu.cn, Sarah Safdar, Jiazhen Huo, Hakeem-Ur Rehman, Raza Ali Rafique

Emergency department (ED) overcrowding in the territory-tier hospitals (TTH) of China is getting worsens even after enriching with sufficient ED capacity while primary care resources (PCR) are about 41% under-utilization. The government is trying to reduce the outpatient's flow from TTH, promote the utilization of primary care units (PCU), and to establish an efficient referral system between TTH and PCU. We proposed a framework in the public-private healthcare sharing economy perspective to divert outpatients flow before visiting TTH to PCU and then empirically investigating the acceptance. The findings can help to mitigate ED overcrowding from TTH and to achieve optimal utilization of PCR.

3 - The Optimal Use of Antibiotics with Fitness Cost under the Economic Dynamics

Weifen Zhuang, School of Management, Xiamen University, China, Xiamen, China, wfzhuang@xmu.edu.cn

This paper studies the optimal usage policy of antibiotics with fitness cost under the economic dynamics. The objective is to minimize the total treatment and resistance cost subject to the population dynamics by the SIS epidemiological model. We compare the optimal usage policy of antibiotics with zero and positive fitness cost, as well as the different paths leading to the steady state. In contrast to the antibiotics with zero fitness cost (depletable resource) which eventually loses the efficacy by consumption, the antibiotics with positive fitness cost (renewable resource) may remain positive in the steady state by determining the optimal usage quantity.

4 - Does Hit Deliver on its Promise? A Case of Pennsylvania Hospitals

Balaraman Rajan, Assistant Professor, California State University East Bay, Hayward, CA, United States, Dinesh R. Pai, Subhajit Chakraborty

This study examines the relationship between health information technology (HIT) and patient care characteristics for Pennsylvania acute care hospitals. Specifically, we examine the impact of HIT functionalities such as electronic health record (EHR) and health information exchange (HIE) on quality of care measures such as risk-adjusted mortality and risk adjusted readmission rates; hospital efficiency measures such as cost per inpatient day and cost per inpatient admission, and on patient flow measure such as average length of stay. While we find evidence for efficiency improvement, HIT seems to adversely impact patient care and patient flow indicators. The conclusions point to a mixed bag.

■ WA04

CC- Room 204

Advances in High Throughput Data Mining for the Chemical Process Industry

Sponsored: Data Mining

Sponsored Session

Chair: Apratim Bhattacharya

Co-Chair: Sivaraman Ramaswamy

Co-Chair: Ankur Kumar

1 - Using Historical Data to Facilitate Production Scheduling: An Industrial Air Separation Case Study

Ankur Kumar, Linde, 175 East Park Drive, Tonawanda, NY, 14150, United States, ankur_kumar@praxair.com, Calvin Tsay, Michael Baldea

Electricity-intensive air separation units (ASUs) are natural candidates for interacting with the power grid via demand response: excess product can be produced during off-peak hours, stored, and sold during times of peak electricity demand. However, scheduling such operations with detailed process models is often intractable for online deployment. In this work, we take a data-driven approach for scheduling an industrial ASU. We identify low-order dynamic models using historical data, and we solve the associated scheduling problem to show the significant economic benefits of demand response.

2 - A Variational Autoencoder for Nonlinear Process Monitoring

Bhushan Gopaluni, University of British Columbia, Vancouver, BC, Canada, bhushan.gopaluni@ubc.ca, Kai Wang, Michael Forbes, JUnghui Chen, Zhihuan Song

We provide a novel algorithm for nonlinear process monitoring and fault detection. The algorithm is based on Deep Neural Networks (DNNs) which are known to provide highly accurate nonlinear models in the presence of large volumes of data. The latent variables generated by DNNs are often difficult to interpret. We use a variant of DNN called auto-encoder to generate a latent space from the measured variables. In particular, we design this auto-encoder in such a way that the latent variables are orthogonal. The orthogonality of the latent variables helps us in developing a statistical measure for process monitoring and fault detection. We illustrate this novel approach through examples.

3 - A Smart Manufacturing Testbed to Explore the Role of Human Learning in the Machine Learning World

Peter He, Associate Professor, Auburn University, Auburn, AL, United States, qhe@auburn.edu, Devarshi Shah, Jin Wang

The emergence of the industrial Internet of Things (IIoT) and ever advancing computing and communication technologies have fueled a new industrial revolution. In this talk, we will discuss an IIoT-enabled smart manufacturing testbed and develop process inferential models using deep neural networks. We demonstrate that rote applications of deep/machine learning algorithms may result in underperforming models that lead to incomplete or misleading conclusions, while by incorporating domain knowledge and human learning, simple and robust models can be developed that significantly outperform machine learning alone.

4 - An Adaptive Alarm Prioritization, Reduction, and Optimization Algorithm for Enhanced Process Safety

Rui Nian, University of Alberta, Edmonton, AB, Canada, Jinfeng Liu, Biao Huang

This study combines reinforcement learning (RL) and data mining to improve alarm systems. The algorithm is threefold: 1) Apply RL to learn value functions online or using historical data via a reward function designed based on safety and production considerations. 2) Group common alarm successions into alarm sequences. 3) In implementation, new alarms are assigned nuisance scores (NS) corresponding to the state's value; negative scores denote important alarms. Finally, the alarms are sorted by NS in ascending order. This algorithm was simulated on a water treatment plant showing reduction in total alarms of up to 82%. The alarms were also prioritized and prioritization has adaptive capabilities.

■ WA05

CC- Room 205

Data Science and Machine Learning: Methods and Applications

Sponsored: Data Mining

Sponsored Session

Chair: Xiaorui Zhu

Co-Chair: Brittany Green

1 - Protecting Privacy of Household Panel Data

Shaobo Li, Asst. Professor, University of Kansas, Lawrence, KS, United States, Matthew Schneider, Yan Yu, Sachin Gupta

We investigate how vulnerable the widely used consumer/household panel data is to intruders who intend to re-identify individual customers through linking to external databases. With the evidence of low privacy-preserving being shown, we establish a framework to protect household panel data without reducing the commercial value. That is, retailers and manufacturers are able to use the household panel data to perform marketing research such as modeling brand choice, while they are not able to re-identify individuals by using external dataset. We demonstrate our framework using IRI household panel data, where we use the yogurt category for assessing the data utility with a brand choice model.

2 - Machine-Learning Approaches for Hedge Fund Return Prediction and Fund Selection

Wenbo Wu, Asst. Professor, University of Texas San Antonio, San Antonio, TX, United States

Various machine learning methods including the least absolute shrinkage and selection operator, random forest, gradient boosting, and deep neural network are applied to select superior funds within major hedge fund style categories into the investment portfolios based on the predicted future returns.. Utilizing the predictive power of advanced machine learning methods, a set of predictive features are derived from historical returns. The empirical results demonstrate the remarkable advantages of the machine learning approach in the out-of-sample performance compared to the benchmarks.

3 - Tree-based Algorithm for Observational Study

Yuyang Zhang, PhD Candidate, Ohio State University, Columbus, OH, United States, BO LU

The subpopulation effects are required when the treatment effect varies systematically with a different part of the data. For this reason, we propose a strategy that identifies the subpopulation structure via tree-based methods. When the number of the subgroups is small, two tree-based methods, Classification and Regression Tree (CART) and Causal Tree (CT) are applied in this study. When the number of subgroups is large, the corresponding forest methods are considered to estimate the subpopulation effects. Based on the results of extensive simulation studies using pre-identified potential subpopulation indicators, the CART performs slightly better than CT.

4 - Tree-based Method for Longitudinal Data

Brittany Green, University of Cincinnati, Carl H. Linder School of Business, 2925 Campus Green Dr., Cincinnati, OH, 45221, United States, Peng Wang

Decision trees for longitudinal data are flexible and powerful predictive models which incorporate nonlinearity yet preserve interpretability. We propose an algorithm to incorporate time varying covariates, eliminate selection bias and avoid estimating the correlation structure between subjects' observations at each node. We use a quadratic inference function classifier along with tests of independence to improve prediction and eliminate selection bias. Numerical experiments and a study of an online health clinic demonstrate performance.

5 - Demystifying Differences between Bankruptcy and Other Failures in Terms of Major Drivers and Risk-Return Relationship

Xiaorui Zhu, University of Cincinnati, Lindner College of Business, Blue Ash, OH, 45236, United States, Yan Yu, Shaonan Tian

We consider a broad definition of failure and dissect distress firms into bankruptcy and other failures that are due to financial reasons other than bankruptcy. Then, we demystify the differences between bankruptcy and other failures from two sides: major drivers and risk-return relationship. Firstly, we apply the LASSO variable selection and find different drivers for two groups of distress events. Secondly, we find factors in valuation models perform differently for bankruptcy and other-failure firms. Our results shed some new lights on the distress puzzle that financially more distressed stocks earn lower returns.

■ WA06

CC- Room 209

Data Oriented Performance Evaluation

Sponsored: Data Mining

Sponsored Session

Chair: Wade Cook, York University

Chair: Joe Zhu, Worcester Polytechnic Institute, School of Business, Worcester, MA, 01609, United States

1 - A Two-stage DEA Problem with Shared Outputs: Modeling Efficiency in Regional Innovation Systems

Sonia V. Avilés-Sacoto, Associate Professor, Universidad San Francisco de Quito, Quito, Ecuador, svaviless@usfq.edu.ec, Wade D. Cook, David Güemes-Castorena, Joe Zhu

Regional innovation systems literature usually focuses on the comparative performance of different regions and analyzes how each region is utilizing its own dedicated resources. This paper uses DEA to study a region in Mexico and the companies within that region with the aim being to identify which of those companies are using the available resources in the best way. The problem in this setting is that some inputs and outputs are shared among the companies in each industry. To address this, the current article presents a modified DEA methodology for measuring efficiency in situations where DMUs share outputs/inputs with other units within the same group.

2 - Service Quality and Efficiency in the U.S. Airline Industry

Sepideh Kaffash, Suffolk University, Boston, MA, United States, skaffash@suffolk.edu, Reza Kazemi Matin, Marianna Marra

This paper investigates the impact of service quality on American airlines efficiency. We analyze a sample of quarterly data of 13 airlines during the period of 2005-2015. We employ a network Data Envelopment Analysis (DEA) approach. First, we propose a new approach to calculate efficiency scores dealing with negative data; secondly, we used the second step of the Simar and Wilson method to regress the efficiency scores with the variable of interest. The results of this study could inform policy and managerial decision

3 - Dynamic Innovation Performance Evaluation for High-tech Companies Using a Network Data Envelopment Analysis Approach

Anyu Yu, Tongji University, Shanghai, China, Joe Zhu

This study aims to examine dynamic innovation performance for China's 506 high-tech companies. Overall company innovation process is conceptualized as R&D and commercial processes. We developed an innovation index that measures the overall innovation performance, which integrated by a R&D index and a commercialization index. A network DEA model is developed to compute the innovation index and its components. A dynamic network model is further extended to represent multi-period processes. One difficulty is programming solving is complex and nonlinear. Thus second order cone programming and nested partitions strategy are integrated to locate the global optimal solution for a large sample.

4 - Performance Evaluation Regardless the Relationship between the Numbers of Units and performance Metrics

Dariush Khezrimotlagh, Pennsylvania State University, Harrisburg, PA, United States, dk@psu.edu, Joe Zhu, Wade D. Cook

Performance measurement is an essential approach to assess how well decision making units (DMUs) are managed. A rule of thumb says that the number of DMUs should be at least three times the numbers of input-output factors. A delta-neighbor technique is discussed to allow discrimination between DMUs regardless the relationship between the numbers of DMUs and inputs-outputs. The technique ranks all DMUs and increases the discrimination power of data envelopment analysis (DEA). Several simulation experiments and real-life applications are designed to examine the power of the delta-neighbor technique. The results strongly support the advantages of the technique versus conventional DEA models.

5 - Efficiency Measurement for Hierarchical Situations

Wanghong Li, York University, North York, ON, M2N 0C2, Canada, whli@schulich.yorku.ca

The measurement and monitoring of the efficiency of processes in organizations has become an important undertaking in today's competitive environment. A fundamental tool for this undertaking is data envelopment analysis (DEA). The current paper looks at a problem setting somewhat related to a multistage situation but pertaining to a particular form of hierarchical structure. We develop a DEA-like methodology that evaluates, in a two-stage manner, both the efficiency of the sub-units and of the aggregates of those subunits (the plants). This two-stage approach is implemented in such a way that optimization is done both at the plant and subunit levels.

6 - A Global Evaluation of CSR: A Weight-constrained Approach

Chien-Ming Chen, Nanyang Technological University-Singapore, 50 Nanyang Avenue, Singapore, 639798, Singapore, Sheng Ang

CSR is a broad concept concerning company practices across multiple social dimensions. While different aggregation weights have been proposed in the literature, there is no clear guideline as for how we can use these weights to rank CSR performance. To address this issue, we develop a novel DEA method with special weight constraints. We use a panel of global KLD data as a case study.

■ WA07

CC- Room 210

Data Visualization Tools in Decision Making and Data Mining

Sponsored: Data Mining

Sponsored Session

Chair: Mehdi Behroozi

1 - Clinical Gait and Balance Screening for the Risk Assessment of Falls in Elderly Population Utilizing Machine Learning Techniques

Venous Roshdibenam, University of Iowa, Iowa City, IA, United States, venous-roshdibenam@uiowa.edu, Stephen Baek

Falling is an increasingly important public health problem which can cause serious and fatal injuries among elderly population. Although the CDC has developed an initiative to intervene for fall risks using clinician's evaluation, it is expensive and time-consuming. Hence, we need to find some algorithms that can be both precise and fast in evaluation. We utilize subjects' gait acceleration and angular velocity signals along with the geriatrician's evaluation of fall risk and exploit Convolutional Neural Networks (CNNs) to create a fall risk prediction algorithm. Our CNN model not only performs the prediction with high accuracy, but also learns the gait patterns and features that result in fall.

2 - Data Visualizations to Analyze Railroad Operations and Safety

Trefor Williams, Professor Emeritus of Civil Engineering, Rutgers University, Piscataway, NJ, United States, tpw@soe.rutgers.edu, Christie Nelson, John F. Betak

Railroads in the United States collect data about accidents, maintenance activities, track conditions and operations. Data visualization can be used on this data to identify trends and problems from diverse data sources. Data visualization allows dashboards of visualizations that can be easily interpreted by railroad operating personnel. This presentation will show the application of data visualization to the analysis of railroad grade crossing accidents and to the analysis of the effects of maintenance work on train performance for a short line railroad.

3 - Using Optimization Techniques in Treemap Partitioning

Reyhaneh Mohammadi, Northeastern University, Boston, MA, 02148, United States, mohammadi.re@husky.neu.edu

In data visualization field, treemap are used to display hierarchical data with a space-filling approach. This method partitions a shape into some nested shapes. One of the important factors in organizing a treemap is creating shapes which are fat enough to be visible. The other factor is preserving the order of information. Currently there are several algorithms for partitioning a treemap most of them ignoring one factor to make the other factor better. In this research, we aim to combine optimization techniques and computational geometry structures such as "Voronoi diagrams", "Power diagrams" and "Delaunay triangulations" to develop treemaps which are both more informative and perceivable.

4 - Understanding Complex Ecosystems Using Text Mining and Interactive Visualization

Hyunwoo Park, Ohio State University, School of Interactive Computing, 85 5th Street Nw, Columbus, OH, 30332, United States, park.2706@osu.edu, Rahul C. Basole

We present the design and implementation of an interactive visual analytic tool that leverages advanced text mining and graph visualization techniques to help decision makers understand the complex public narrative surrounding business ecosystems.

■ WA08

CC- Room 211

Joint Session AI/Practice Curated: Artificial Intelligence Applications in Transportation

Sponsored: Artificial Intelligence

Sponsored Session

Chair: Mohammad Dehghani

1 - A Deep Learning Based Framework for Connected and Autonomous Vehicle Simulation

Sikai Chen, Purdue University, West Lafayette, IN, United States, chen1670@purdue.edu, Yue Leng, Samuel Labi

Motor vehicle crashes are one of the leading cause of deaths worldwide. For a vast majority of these crashes, human error continues to be a dominant contributory factor. It is expected that the adoption of connected and autonomous vehicles (CAVs) will drastically reduce human errors in driving. To overcome CAV testing limitations at in-service roads and test tracks, this paper proposes a deep learning based CAV simulation framework, which incorporates human prior knowledge and temporal information. The proposed framework facilitates CAV testing and safety impact evaluation in a safe setting.

2 - A Data-driven Trajectory Generation Model in Terminal Airspace

Ning HONG, PhD Candidate, City University of Hong Kong, Kowloon, Hong Kong, neil.hong@my.cityu.edu.hk, Lishuai Li

Quantifying and predicting uncertainties of aircraft trajectories is important when designing or modifying standard routes in an airspace. In this paper, we propose a deep learning method to predict actual aircraft trajectories given a new standard instrument departure (SID) or standard terminal arrival route (STAR) design by learning from historical ADS-B data. We find that the method captures statistical properties of aircraft trajectories and can generate realistic trajectories.

3 - Cooperative Intersection Management of Connected and Autonomous Vehicles

Anye Zhou, Georgia Institute of Technology, Atlanta, GA, United States

We address the problem of controlling connected and autonomous vehicles through an intersection without traffic signals. A two-layer optimization framework is proposed to guarantee safety and increase throughput at the intersection. Results from numerical simulations will be used to illustrate the ability of the proposed method to enhance capacity and efficiency of the intersection compared to traditional signal-timing control.

4 - Machine Learning and Deep Learning Methods Applied to Forecasting Transit Demand

Brian Mayer, Virginia Polytechnic Institute and State University, Blacksburg, VA, United States, bmayer@cs.vt.edu

Machine Learning and Deep Learning Methods Applied to Forecasting Transit Demand

■ WA09

CC- Room 212

Online and Reinforcement Learning

Sponsored: Artificial Intelligence

Sponsored Session

Chair: Theja Tulabandhula, UIC, Chicago, IL, United States

1 - Oboe: Collaborative Filtering for AutoML

Madeleine Udell, Cornell University, Ithaca, NY, United States, udell@cornell.edu

Algorithm selection and hyperparameter tuning remain two of the most challenging tasks in machine learning. Automated machine learning (AutoML) seeks to automate these tasks toenable widespread use of machine learning by non-experts. This talk introduces Oboe, a collaborative filtering methodfor time-constrained model selection and hyperparameter tuning. Experiments demonstrate that Oboe delivers state-of-the-art performance faster than competing approaches on a test bed of supervised learning problems. Moreover, the success of the bilinear model used by Oboesuggests that AutoML may be simpler than was previously understood.

2 - Combining No-regret and Q-learning

Ian Kash, University of Illinois at Chicago, Chicago, IL, United States

Most reinforcement learning algorithms do not provide guarantees in settings with multiple agents or partial observability. A notable exception is Counterfactual Regret Minimization (CFR), which provides both strong convergence guarantees and empirical results in settings like poker. We seek to understand how these guarantees could be achieved more broadly. To take a first step in this direction, we introduce a simple algorithm, local no-regret learning (LONR), which captures the spirit of CFR, but can be applied in settings without a terminal state. We prove its convergence for the basic case of MDPs and discuss research directions to extend our results to address richer settings.

3 - Exploiting Correlation in Finite-armed Structured Bandits

Gauri Joshi, Carnegie Mellon university, Pittsburgh, PA, United States

We consider a structured multi-armed bandit problem in which mean rewards of different arms are related through a hidden parameter and propose generalizations of UCB and Thompson sampling for this problem. Our approach is based on exploiting the structure in the problem to identify some arms as sub-optimal and pulling them only O(1) times. This results in a significant reduction in cumulative regret and in fact our algorithm achieves bounded (i.e., O(1)) regret whenever possible. Moreover, our model subsumes several previously studied frameworks such as Global, Regional and Structured bandits with linear rewards.

4 - Structural Causal Bandits: Where to Intervene?

Elias Bareinboim, Columbia University, New York City, NY, United States, eb@cs.columbia.edu

We study a version of the structural causal bandit problem (Lee and Bareinboim, 2018) where pulling an arm corresponds to an intervention and not all variables are manipulable. We develop a procedure that uses partially specified causal knowledge and identifies the optimal arms in structural bandits with non-manipulable variables. We can also uncover non-trivial dependence structure among the possibly-optimal arms. Finally, we show empirically that MAB solvers enhanced with causal knowledge and leveraging the newly discovered dependence structure among arms consistently outperform their causal-insensitive counterparts.

5 - Bandits with Temporal Stochastic Constraints

Theja Tulabandhula, UIC, FF07 Ajanta Vihar, Yelahanka, Chicago, IL, United States, Priyank Agrawal

We study the effect of impairment on stochastic multi-armed bandits and develop new ways to mitigate it. Impairment effect is the phenomena where an agent only accrues reward for an action if they have played it at least a few times in the recent past. It is practically motivated by repetition and recency effects in domains such as advertising and vocational training. Impairment can be naturally modeled as a temporal constraint on the strategy space, and we provide two algorithms that achieve sub-linear regret, each working with different assumptions on the impairment effect. Our work complements recent work on modeling delays and corruptions in multi-armed bandits.

■ WA10

CC- Room 213

Social Media Analytics for Smart Health

Sponsored: Social Media Analytics

Sponsored Session

Chair: Theodore T Allen, Ohio State University, Columbus, OH, 43210-1271, United States

1 - In Search of the True Worth of a 'Like': A Network Externality Approach

Gohar Khan, University of Waikato, New Zealand, Manar Mohaisen, Matthias Trier

We argue that the social media returns are derived not only from the actions per se but also from the additional exposure that results from the network externality associated with these actions. Hence, leveraging the notion of network externality, we proposed, modelled, and experimentally measured network and discrete ROI.

2 - TOPIC: Framing Effect on Social Lending Platforms: A Topic Modelling Approach

Shivendu Pratap Singh, Waikato University, Waikato University, Waikato, New Zealand

Social lending platforms explore ways to engage lenders on the platform and help those making informed choices. We explore the effect of content framing on lending selection by network of lenders on lending platforms. Using topic modelling, we measure the impact of content framing on financial choices by lenders.

3 - Influencing Donation Choice in Social Networks After Disasters

Trilce Encarnacion, Rensselaer Polytechnic Institute, Jonsson Engineering Center,Troy, NY, 12180, United States

In order to effectively influence donation choice in a social network setting after disasters, a network influence model is formulated, incorporating behavior research regarding individuals' attitudes. Operations research techniques are used to select an appropriate influencing strategy to effect change in donation choice towards better donation practices after disasters.

■ WA11

CC- Room 214

Queueing Theory and Applications

Sponsored: Applied Probability

Sponsored Session

Chair: Vahid Sarhangian, University of Toronto, Toronto, M5S 3G8, Canada

1 - The Power of Two in Queue Scheduling

Yan Chen, Columbia University, New York, NY, 10027, United States, yc3107@columbia.edu, Jing Dong

We study a scheduling policy with two priority classes. In the single-server heavy-traffic regime, our scheduling policy achieves similar scaling for the queue length processes as the shortest remaining processing time first policy. Our analysis quantifies on how the tail of the service time distribution will affect the benefit one can gain from smart scheduling policies. When the service time information is estimated/predicted, we further analyze how prediction error will affect the performance our scheduling policy. Our results provide insights on the interplay between the service time distribution and the estimation error distribution on system performance.

2 - Staffing and Scheduling to Differentiate Service in Time-varying Multiclass Service Systems

Xu Sun, University of Florida, Gainesville, FL, United States

Motivated by the Canadian triage and acuity scale (CTAS) that classifies patients in the emergency department into five acuity levels, we consider a joint staffing and scheduling problem for a multiclass queue with the objective of achieving differentiated service for each customer class. We propose new control principles (via staffing and scheduling) to guarantee that each class can achieve its prescribed performance target. Effectiveness of proposed policy is substantiated by limit theorems. We also conduct computer simulations to provide engineering confirmation and to gain insights.

3 - Parallel Queues with Arrivals Driven by a Discrete Choice Model

Yichuan Ding, Assistant Professor, McGill University, University of British Columbia, Montreal, QC, V6T 1C3, Canada, daniel.ding@mcgill.ca

We consider a parallel-queue system in which each queue is served by a dedicated service provider. The arrival process is driven by a discrete choice model, in which the mean arrival rate of a queue is a function of the queue lengths and the service attributes. We show that with such arrival rate functions, even without Lipschitz-continuity assumption, the queue-length process converges to a unique equilibrium, and the diffusion limit process is a reflected multi-dimensional Ornstein-Uhlenbeck process centered at that equilibrium. We then use these properties to derive the optimal staffing levels at each location subject to service level constraints.

4 - Discharge Control with Patient Readmissions: A Decentralized Optimization Approach

Hossein Abouee Mehrizi, University of Waterloo, Department of Management Sciences, Waterloo, ON, N2L 3G1, Canada, haboueem@uwaterloo.ca, Ya-Tang Chuang, Michael Kim, Xinyuan Zhang

This paper concerns discharge control of patients in a hospital considering patient readmissions. We formulate the problem as an MDP where patients' health conditions and readmission dynamics are explicitly modelled. Discharge control of patients with the goal of optimizing the system efficiency is generally intractable as it involves considering the status of patients simultaneously. To overcome this challenge, a decentralized control procedure is proposed where discharge decisions are made patient-by-patient by adjusting some parameters. We show that the proposed procedure achieves the optimality of the integrated system.

■ WA12

CC- Room 2A

Scheduling in Parallel and Distributed Systems

Sponsored: Applied Probability

Sponsored Session

Chair: Mor Harchol-Balter, Carnegie Mellon University, Pittsburgh, PA, 15213, United States

1 - Optimal Scheduling of Parallel Jobs

Benjamin Berg, PhD Student, Carnegie Mellon, Pittsburgh, PA, 15213, United States, bsberg@cs.cmu.edu

Nearly all data center workloads can exploit parallelism. When a job is parallelized across multiple servers it will complete more quickly, but jobs receive diminishing returns from being allocated additional servers. Thus, it is not clear how to allocate servers to each job in order to minimize overall mean response time. Specifically, one must balance a tradeoff between granting priority to short jobs and maintaining overall system efficiency. We derive the optimal policy for allocating servers to jobs in the case where job sizes are unknown and exponentially distributed, as well as the case where job sizes are known to the system. Joint with: Jan-Pieter Dorsman, Rein Vesilo and Mor Harchol-Balter

2 - Online Algorithms for Unrelated Machine Stochastic Scheduling

Benjamin Moseley, Assistant Professor, Carnegie Mellon University, 5000 Forbes Av, pittsburgh, PA, 15208, United States, moseleyb@andrew.cmu.edu

We derive the first performance guarantees for a combinatorial online algorithm that schedules stochastic, nonpreemptive jobs on unrelated machines to minimize the expectation of the total weighted completion time. Prior work on unrelated machine scheduling with stochastic jobs was restricted to the offline case and required sophisticated linear or convex programming relaxations for the assignment of jobs to machines. Our algorithm is purely combinatorial, and therefore it also works for the online setting. As to the techniques applied, this paper shows how the dual fitting technique can be put to work for stochastic and nonpreemptive scheduling problems.

3 - Load Balancing with Ultra Low Communication Overhead

Weina Wang, Carnegie Mellon University, Pittsburgh, PA, 15213, United States

We consider load balancing of parallelizable jobs in a system with a large number of servers. In this model, each job consists of a batch of parallel tasks that need to be placed onto the servers upon arrival. Due to the large size of the system, the communication overhead of a load-balancing policy is prohibitive if it samples the queue lengths of too many servers for each job. In this work, we study two policies: batch-filling and (batch) power-of-d-choices. We explore a new regime for batch-filling where fewer than one sample is incurred per task. We show that with this ultra low communication overhead, batch-filling achieves comparable job delay to power-of-2-choices, which uses two samples per task.

4 - Load Balancing Guardrails: Keeping Your Heavy Traffic on the Road to Low Response Times

Isaac Grosof, Carnegie Mellon University, CMU, Pittsburgh, PA, United States, igrosof@cmu.edu, Ziv Scully, Mor Harchol-Balter

Load balancing systems, comprising a central dispatcher and a scheduler at each server, are widely used in practice, and their response time has been extensively studied. While much is known for the case where the servers use First-Come-First-Served (FCFS) scheduling, to minimize mean response time we must use Shortest-Remaining-Processing-Time (SRPT) scheduling at the servers. Much less is known in this scenario. Unfortunately, traditional dispatching policies often have poor performance in systems with SRPT servers. We devise guardrails, a simple fix that can be applied to any dispatching policy to ensure optimal mean response time under heavy traffic when used in a system with SRPT servers.

■ WA13

CC- Room 2B

Forecasting I

Contributed Session

Chair: Nicolò Bertani, INSEAD, Boulevard de Constance, Fontainebleau, 77300, France

1 - A Hybrid Approach with Step-size Aggregation to Forecasting Hierarchical Time Series

Hakeem Ur Rehman, Shanghai Jiao Tong Univesity, Shanghai, China, hakeem@mail.sjtu.edu.cn, Guohua Wan, Raza Ali Rafique

We develop a new hybrid approach with step-size aggregation for hierarchical time series forecasting, which performs better compared to either the "top-down" approach or the "bottom-up" approach. The new approach is a weighted average of the two classical approaches with the weights being optimally chosen for all the series at each level of the hierarchy to minimize the variance of the HA forecast errors. We demonstrate the hierarchical forecasting approaches performance by applying it to the monthly data of 'Industrial' category of M3-Competition as well as on Pakistan energy consumption data.

2 - Machine Learning Blending Approach to Improving Forecasting Accuracy

Misuk Lee, Seattle University, Seattle, WA, United States, leem@seattleu.edu, James Lee

This research suggests a machine learning architecture for more accurate forecasting. We examine several different forecasting models including traditional time-series models and machine learning models, and propose neural network blending models to improve forecasting accuracy. Using real-life hotel price data, we provide empirical results of the proposed approach along with a comparison to traditional forecasting methods.

3 - Portfolio of Time Series Forecasting Models to Predict Container Throughput at the Port

Sonali Shankar, Indian Institute of Technology Delhi, Hauz Khas, New Delhi, 110016, India, 03shankarsonali@gmail.com, P.Vigneswara Ilavarasan

The paper proposes a portfolio of time series forecasting models constituting 1) conventional econometric model like ARIMA, TBATS etc. ; 2) Machine learning based model like neural network; 3) Hybrid model; 4) Deep learning based long short-term memory (LSTM) network. The models are evaluated on the real-world dataset of container throughput at the port of Singapore. The dataset contains monthly throughput generated at the port from year 1995-2018. The performance metrics is evaluated to measure bias, variance and accuracy. The LSTM network is found to outperform other widely used time series methods. The results obtained are further substantiated via Diebold-Mariano statistical test.

4 - Revisiting Bottom-Up Forecasting for Hierarchical Time-Series Data

Nicolò Bertani, INSEAD, Fontainebleau, France, nicolo.bertani@insead.edu, Ville Satopaa, Shane Jensen

Time-series are often structured in a hierarchy. For instance, tourism is recorded and forecasted at regional, state, and national level. Reconciliation methods claim to use "information" in the hierarchy, modelling each node independently and enforcing consistency ex-post. But hierarchies are merely summing constraints, and data generation occurs at the disaggregated level. We show that the hierarchy carries no informational value in the minimization of squared residuals: the leaves and their contemporaneous covariance suffice. We revisit the classical bottom-up methods accordingly, obtaining hierarchical uncertainty measures - a difficult task, if at all possible, in reconciliation.

■ WA14

CC- Room 302

Last Mile Delivery Challenge: Food and Grocery Retailing

Sponsored: Manufacturing & Service Oper Mgmt

Sponsored Session

Chair: Xuanming Su, University of Pennsylvania, Philadelphia, PA, 19104, United States

Chair: Chloe Kim Glaeser, Chapel Hill, NC, 27514, United States

1 - Product Line Management for On-demand Services

Kaitlin Daniels, Olin Business School, Washington University in Saint Louis, St. Louis, MO, United States

We study an on-demand service platform's capacity management problem when the platform offers vertically differentiated services. We show that the relationship between the cost of capacity and the utilization of capacity in this setting leads to job allocation polices that differ from traditional settings. We discuss implications for settings with strategic consumers.

2 - Order Assignment with Travel Time Predictors

Sheng Liu, University of California, Berkeley, Berkeley, CA, 94709, United States, lius10@berkeley.edu, Long He, Zuo-Jun Max Shen

We study how delivery data can be applied to improve on-time performance in last mile delivery service. Motivated by a food delivery service provider, we discuss a data-driven framework to model the delivery performance and optimize the decision on how to assign orders to drivers. Leveraging classical results in routing literature and machine learning approaches, we propose a prediction model for the delivery travel time, which captures driver's routing behavior in practice. We then demonstrate how we can integrate the prediction model with stochastic and robust optimization models.

3 - Online Food Ordering Platforms: Commission Rates and Delivery Fees

Chloe Kim Glaeser, University of North Carolina, Kenan-Flagler Business School, 714 Greenwood Rd, Chapel Hill, NC, 27514, United States, chloe_glaeser@kenan-flagler.unc.edu, Xuanming Su, Jaelynn Oh

We study the commission rates and delivery fees of online food ordering platforms. We document how much a platform can benefit from jointly determining commission rates and delivery fees.

4 - Grocery Store Density and Food Waste

Elena Belavina, Associate Professor, Cornell University, Ithaca, NY, United States, eb733@cornell.edu

Food waste is a major contributor to carbon emissions. Identifying market conditions that can decrease waste is thus important to combat global warming. We study the impact of grocery-store density on the waste generated at stores and households. Our analysis shows that higher density reduces food waste up to a threshold; it leads to higher food waste beyond this threshold. Calibration using grocery industry, economic and demographic data reveals that actual store density in most American cities is well-below this threshold, and modest increases in store density substantially reduce waste; e.g. in Chicago, just 3-4 more stores (per 10 sq-km) can lead to a 6-9% waste reduction.

■ WA15

CC- Room 303

Operations/Marketing Interface

Sponsored: Manufacturing & Service Oper. Mgmt/Service Operations

Sponsored Session

Chair: Yasar Levent Kocaga, Sy Syms School of Business, New York, NY, 10033, United States

1 - Perils and Benefits of Free Trials in Large Scale Service Systems: an Operational Perspective

Yasar Levent Kocaga, Associate Professor of Operations Management, Sy Syms School of Business, Belfer Hall Room # 403/A, 2495 Amsterdam Ave, New York, NY, 10033, United States, kocaga@yu.edu

We consider a firm that serves a market of price and delay sensitive customers and that has optimized the static per use price and capacity, before offering free trials to generate further demand. We first analyze the case where the firm offers free trials without changing the capacity or price, and we show that the benefit of offering free trials is of second order (and thus negligible for large systems), if beneficial at all. Next, we consider the case where capacity can be adjusted, and show that offering free trials can yield significant benefits.

2 - Optimal Seller-induced Learning: Joint or Decoupled Product Trials

Eren Basar Cil, University of Oregon, Lindquist College of Business, Eugene, OR, 97403-1208, United States, erencil@uoregon.edu, Michael Pangburn, Monire Jalili

We study a firm selling multiple products to heterogeneous customers. To help customers resolve valuation uncertainty, the firm offers product trials, joint or decoupled, as are common in practice for vineyards. We investigate the trial structure and pricing to understand when joint trials are the optimal form of seller-induced learning.

3 - Service Product Design and Consumer Refund Policies

Xiao Huang, Associate Professor, John Molson School of Business, Concordia University, 1455 De Maisonneuve Blvd. West, Montreal, QC, H3G 1M8, Canada, xiao.huang@concordia.ca, Dan Zhang

We consider the joint product customization and refund policy decisions of a monopolistic firm selling to a heterogeneous customer base. Our results shed light on how customers' valuation uncertainty, characterized by the ex-ante signal quality and the ex-post valuation heterogeneity, drives the interaction between product line and refund policy designs. Interestingly, allowing refunds may lead to a variety reduction in the product line, and partial refunds may arise even though our setup does not involve demand uncertainty, capacity, competition, or channel conflicts. We investigate the firm's information provision strategies and discuss practical implication of the results.

4 - Selling Freemium Products to Loss Averse Consumers

Sami Najafi-Asadolahi, Santa Clara University, Santa Clara, CA, United States, Sajjad Najafi, Nishant Mishra, Andy A. Tsay

We consider a firm selling two versions of a single product, a free version for free and a premium version at a regular price, to consumers who are loss-averse. We show that when consumers become slightly dissatisfied with the free version, they are more willing to buy the premium version.

■ WA16

CC- Room 304

Empirical Research in Service Systems

Sponsored: Manufacturing & Service Oper. Mgmt/Service Operations

Sponsored Session

Chair: Qiuping Yu, Kelley School of Business, Indiana University, Kelley School of Business, Indiana University, Bloomington, IN, 47405-1701, United States

1 - Low-acuity Patients Delay High-acuity Patients in an Emergency Department

Danqi Luo, Stanford University, 655 Knight Way, Stanford, CA, 94305, United States, dluo@stanford.edu, Mohsen Bayati, Erica Plambeck

This work provides theoretical and empirical evidence that in an ED, the arrival of an additional low-acuity patient significantly increases high-acuity patients' wait times. Two stylized models are built to provide theoretical lower bounds for the extra wait times caused by a low-acuity patient on the high-acuity patient wait times. Empirically, to estimate the effect, we propose a method motivated by queueing theory and involving quasi-randomization in the wait time forecast at triage for low-acuity patients, which influences their propensity to leave without being seen.

2 - Linking Delay Announcements, Abandonment, and Service Time: A Behavioral Perspective

Eric Michael Webb, University of Cincinnati, Cincinnati, OH, 45226, United States, Qiuping Yu, Kurt M. Bretthauer

Using field data from a call center, we study how delay announcements induce reference-dependent behavior that impacts customer abandonment and service time. Customers who have waited less (more) time than expected are experiencing a gain (loss) in time. These gains and losses impact both abandonment behavior and service time. A loss (gain) in waiting time increases (decreases) the likelihood to abandon. The loss is more impactful than the same sized gain, signifying that customers are loss averse. Interestingly, the effect of loss aversion carries over into service. Conditional on the same total waiting time, customers who incur a loss in waiting time while in queue spend longer in service.

3 - Engineering the Delay Announcement to Improve Patient Satisfaction

Sina Ansari, Tuck School of Business, Hanover, NH, United States, Sina.Ansari@tuck.dartmouth.edu, Seyed Iravani, Laurens G. Debo

Using predictive analytics and two years of hospital data, an institution specific application is developed to predict wait-times. We use linear regression models with time and patient-related control variables to identify the effect of delay announcement on patient waiting experience and understand the underlying dynamics. We observe that providing patients with their estimated wait-times improves their self-reported satisfaction up to 18%. The highest increase in wait-time satisfaction in our experiment was obtained by adding 40 to 80 minutes to the expected wait-time (which corresponded with reporting the 70th percentile of the wait time distribution).

4 - Can "Very Noisy" Information Go a Long Way? An Exploratory Analysis of Personalized Scheduling in Service Systems

Seyed Emadi, UNC-Chapel Hill, Chapel Hill, NC, United States, seyed_emadi@kenan-flagler.unc.edu, Rouba Ibrahim, Saravanan Kesavan

In this work, we focus on the implementation of personalized scheduling policies which exploit noisy individual customer information. In particular, we consider the shortest job first policy with noisy service time predictions. We use a combination of three methodologies. Through our empirical study, we investigate how personalized scheduling using service-time predictions from a real call-center performs in practice. Then, we use both simulation modeling and queueing theory to deepen our understanding into that operational performance.

■ WA17

CC- Room 305

Learning and Robust Optimization in Service Operations

Sponsored: Manufacturing & Service Oper. Mgmt/Service Operations

Sponsored Session

Chair: Chaithanya Bandi, 1987, 1987, Evanston, IL, 60208, United States

1 - Using Geometry for Improving Policies in Multistage Robust Optimization

Eojin Han, Northwestern University, Evanston, IL, 60208, United States, eojinhan2020@u.northwestern.edu, Chaithanya Bandi, Omid Nohadani

We develop a framework to construct a hierarchy of dynamic policies for multistage robust optimization problems. We leverage the geometry of the uncertainty set and the geometry imposed by the set of constraints to lift the uncertainty set to higher dimensions, which leads to generalized non-linear dynamic policies. Numerical experiments demonstrate that our framework significantly improves over linear decision rules without losing computational tractability.

2 - Robust Lot Sizing Problem under Adversarial Demand Uncertainty

Omar El Housni, Columbia University, New York, NY, 10027, United States, oe2148@columbia.edu, Vineet Goyal, David B. Shmoys

We consider a two-stage robust lot-sizing problem in a network where each node is facing an uncertain demand that is realized in the second stage. In the first stage the decision maker needs to decide the inventory levels for each node while in the second stage he can make recourse transportation decisions after observing the uncertain demands. We model uncertainty in the second stage using a budget of uncertainty set and present algorithms with provable guarantees.

■ WA18

CC- Room 306

Emerging Operations Management Problems on 3D Printing

Sponsored: Manufacturing & Service Oper. Mgmt/Supply Chain

Sponsored Session

Chair: Jing-Sheng Jeannette Song, Duke University, Duke University, Durham, NC, 27708-0120, United States

Chair: Yue Zhang, Pennsylvania State University, Pennsylvania State University, University Park, PA, 16827, United States

1 - Managing Self-replicating Innovative Goods

Zhankun Sun, City University of Hong Kong, 7-268, 7/F, Academic 3, Tat Chee Avenue, Kowloon, Hong Kong, zhanksun@cityu.edu.hk, Bin Hu

We study optimal production and sales policies for a manufacturer of self-replicating innovative goods. We adopt the continuous-time optimal control framework and marry a self-replication model on the production side to the canonical innovation diffusion model on the demand side. By analyzing the model, we identify Strong and Weak Replicability regimes wherein production and sales respectively take priority over the other, and fully characterize their distinct optimal policies. These insights prove highly robust in several model extensions, including backlogged demand, repeated purchases, and additional exogenous and endogenous production constraints.

2 - Decentralized Customization with 3d Printing

Ali Kemal Parlakturk, University of North Carolina at Chapel Hill, Kenan-Flagler Business School, Chapel Hill, NC, 27599-3490, United States, Jayashankar M. Swaminathan, Nagarajan Sethuraman

In this paper, we study the trade-offs involved in decentralized customization enabled by 3D printing at retail stores. We develop an analytical model that considers in-store 3D printing as a component of the firm's broader product line strategy. Managerial insights from our novel model can guide the adoption of 3D printing at retail stores.

3 - 3d Printing of Spare Parts via LP License Contracts

Jing-Sheng Jeannette Song, Professor, Duke University, Fuqua School of Business, Durham, NC, 27708-0120, United States, jssong@duke.edu, Bram Westerweel, Rob Basten

3D printing has the potential to shift supply chains from global networks that rely on centralized production with traditional manufacturing technologies to largely digital networks with decentralized, local 3D printing, i.e., digital inventory. In this paper we propose that the OEM acts as an intellectual property (IP) licensor by selling spare parts designs, rather than physical spare parts. With these designs a buyer can print spare parts locally at much shorter lead times and at lower setup costs. We consider both an OEM who serves multiple identical buyers, and an OEM who serves non-identical buyers. For both cases we characterize the optimal IP license contract.

4 - How 3d Printing and Other Emerging Technologies Can Help MRO Parts Inventory Management

Yu-Ning Liu, Tech Leader, Manufacturing & Supply Chain Analytic, Ford Motor Company, Dearborn, MI, 48105, United States, yliu4@ford.com, Jing Chen, Oleg Gusikhin, William Finkenstaedt

Maintenance, Repair, and Operations (MRO) parts inventory management is challenging. Additive manufacturing, Internet of Things (IoT), big data analytics, machine learning, and new smart mobility logistics models are emerging technologies that enable efficient inventory solutions for different types of MRO parts. There is no single universal strategy that works for all MRO parts due to wide variety of part attributes including usage patterns, lead-time, and cost. We propose the clustering of MRO parts into different groups and discuss the potential strategy to improve inventory management efficiency by leveraging emerging technologies for each MRO part group.

■ WA19

CC- Room 307

Behavioral Operations I

Contributed Session

Chair: Nur Cavdaroglu, Kadir Has University, Bostanci Mah Mehmet Sevki Pasa Cad 27/13, Istanbul, 34744, Turkey

1 - Analyzing Supply Chain Decision Behavior with Online Beer Game

Chialin Chen, National Taiwan University, Taipei, Taiwan, cchen026@ntu.edu.tw, Shu-Jung Sunny Yang, Yi-Chun Wu

The bullwhip effect describes the famous phenomenon where demand variability is typically higher for firms upstream in a supply chain. In this research, we study the factors which influence human supply chain decisions with the online beer game. Decision makers are classified into several groups based on different degrees of inventory fluctuations. A panel data analysis is conducted to study how different decision makers react to demand variation under different settings. Our study explores the behavioral factors of the bullwhip effect in terms of information processing as well different numbers of factors considered in their decision making processes.

2 - The Role of Emotions in Operations Management: An Experimental Analysis of Newsvendors

Santiago Forero, University of Houston, C. T. Bauer College of Business, Houston, TX, United States, sforero@bauer.uh.edu, Norman Johnson, David X. Peng

The influence of emotions on judgment and decision making has received the attention of researchers in several fields, but it has received scant attention in operations management. We conduct a series of experiments to explore how a negative, cognitive-based emotion, impacts ordering decisions made by newsvendors.

3 - Do Attractive People Make a Better Deal? An Investigation of Social Factors in Supply Chain Management

Lyudmyla Starostyuk, University of Texas-Arlington, Arlington, TX, United States, lyudmyla.starostyuk@mavs.uta.edu, Kay-Yut Chen, Edmund L. Prater

Although it is well known that people form impressions of others based on their appearance, little is known about the role of facial character judgments in contracting. We present results of the experiment designed to reveal the effect of attractiveness, trustworthiness and dominance on pricing behavior in a supply chain game. To measure the shift in bounded rationality of a supplier, we apply the quantal choice model.

4 - Eyes on the Game: Eye-tracking Analysis of the Beer Game

Andres I. Musalem, University of Chile, Santiago, Chile, Rene San Martin, Juan Pablo Torres

The beer distribution game is a simulation game designed to illustrate the complexities of inventory decisions within a supply chain. We consider a simplified version of the beer game and use eye-tracking to study the attentional patterns of players. This allows us to study differences between good and bad players in terms of the attention they allocate to the different pieces of information (e.g., initial inventory, demand). We are also able to study differences in attentional strategy depending on the context faced by the players (i.e., positive initial inventory versus backorder).

5 - A Behavioral Experiment Regarding Pricing Decisions

Nur Cavdaroglu, Assistant Professor, Kadir Has University, istanbul, Turkey, nur.cavdaroglu@khas.edu.tr

In this paper, we analyze the pricing decisions of a seller in an environment where there exists a competitor. The demand the seller faces is uniformly distributed, where the average demand increases in the price of the competitor and decreases in her own price. We study the pricing decisions of the seller in a 2x2 design where the first factor is the price of the competitor (either too low or too high with respect to the optimal price of a Nash equilibrium with two homogeneous sellers), and the second factor is the variance of the demand function. According to the preliminary results, the subjects exhibit anchoring behavior (on the price of the competitor) and regret, and decisions worsen with the variance.

■ WA20

CC- Room 308

Using OR/Analytics Methods for Higher Education Process Improvement

Contributed Session

Chair: Scott Warren, University of North Texas, Denton, TX, 76207, United States

1 - Lean Six Sigma Black Belt Higher Education Project

Marsha Jance, Associate Professor of Business Administration, Indiana University East, Richmond, IN, United States

A higher education based Lean Six Sigma Black Belt project will be discussed. The presentation will cover the DMAIC (Define, Measure, Analyze, Improve, and Control) methodology phases for the project and how using the DMAIC methodology lead to improvements in this higher education process.

2 - Lean Six Sigma and Higher Education Improvements

Rebecca Clemons, Assistant Professor, Indiana University EAst, Richmond, IN, United States, reclemon@iu.edu, Marsha Jance

Lean Six Sigma methodology is used to identify areas of improvement in the higher education processes. The authors discuss how analyzing student survey feedback data lead to Lean Six Sigma Black Belt project ideas. The presentation will cover how the DMAIC methodology (Define, Measure, Analyze, Improve, and Control) is applied. An overview of the Lean Six Sigma and higher education literature will also be provided.

3 - Master Scheduling in K-12 Education

Neil Desnoyers, Saint Joseph's University, Philadelphia, PA, United States

For almost all those individuals who are tasked with performing it, the Master Scheduling process in K-12 education is painful. As one K-12 administrator responsible for Master Scheduling in her school commented recently, "...it's a very daunting and time-consuming task." Significant advances in K-12 Master Scheduling have not occurred frequently. In fact, the last significant advance in the field ("block scheduling") was developed over 20 years ago. Improvements in data availability, scheduling algorithms, and programming languages since that time should change the landscape of the problem.

4 - Report on the Development of an Academic Program's Operational Model, Information Systems, and Supporting Documentation to Improve Customer Service

Scott J. Warren, Professor, University of North Texas, Denton, TX, United States, scott.warren@Unt.edu, Matthew Bonhamgregory

In academic departments at universities, operations management is usually created each day and therefore an inefficient process where stakeholders respond to problems as they arise. Lack of an operational model for academic programs has negative consequences. Reactionary operations may fail to capture recruiting leads, provide poor advising service to students during and creates heavy staff workload. This can lead to low morale and costly turnover. This presentation describes the systems engineering research process used to develop a functional operations model for a graduate degree program. We explain our approach to improving customer experience while reducing staff workload.

■ WA21

CC- Room 309

Joint Session MIF/PSOR: Stochastic Models in Disaster Response Logistics

Sponsored: Minority Issues

Sponsored Session

Chair: Diana Gineth Ramirez-Rios, Rensselaer Polytechnic Institute, Troy, NY, 12180, United States

1 - Stochastic Models for Facility Location and Allocation of Relief in Disaster Response Logistics

Diana G. Ramirez-Rios, Rensselaer Polytechnic Institute, Troy, NY, 12180, United States, ramird2@rpi.edu, Jose Holguin-Veras

This research focuses on the facility location and prepositioning of relief distribution in the event of a disaster where decisions made affects total social costs. This includes the private costs associated to logistic operation and the external costs associated to the suffering of the population in need in terms of deprivation costs. The decisions considered are both in the planning and post-disaster stages. In the planning stage, optimal facility location and prepositioning is decided. In the post-disaster stage, decisions are made regarding distribution of relief. Due to the stochastic nature of the problem, several demand patterns and the model aims at minimizing total expected social costs.

2 - A 2-Stage Stochastic Model to Allocate Water in Post-Disaster Environments

Sofia Perez-Guzman, Rensselaer Polytechnic Institute, Troy, NY, 12180, United States, perezs@rpi.edu, Diana Gineth Ramirez-Rios, Mario E. Arrieta-Prieto, Abdelrahman Ismael

This research extends on previous work on anticipation effects caused by the lack of aid in post-disaster environments which focused on the time when aid will be available and conditions go back to normal. The allocation of the aid must also respond to the actual demand for it, i.e. its randomness and its split among the different shelters. The following work develops a two-stage stochastic model that captures the uncertainty from both returning to normal conditions and demand dynamics. This allows incorporating the humanitarian suffering, by using deprivation cost functions, and a dynamic, interrelated and time-dependent demand of aid, by following the Lotka-Volterra model.

3 - Planning Relief Distribution After Disasters Considering Social Costs

Ruben Yie, Universidad del Norte, Barranquilla, Colombia, Johanna Amaya Leal

Coordinating the arrival of relief groups responding to a disaster is a major issue for disaster managers on the ground. This paper describes a methodology to solve the problem of Districting and Vehicle Routing for relief distribution after disasters (D-VRP). Using the total social costs of the operation as objective, the model assigns relief groups to cover small areas (i.e. district) within the impacted zone, and proposes a routing solution to serve the demand of survivors located at the points of distribution. The model considers the resources brought by the relief groups, capacity of available sites, and the needs of the population to minimize human suffering.

■ WA22

CC- Room 310

Joint Session MSOM/SUS/Practice Curated: Sustainable and Socially Responsible Operations

Sponsored: Manufacturing & Service Oper. Mgmt/Sustainable Operations

Sponsored Session

Chair: Can Zhang, Duke University, Durham, NC, 27708, United States

1 - Optimizing First-mile Logistics in Smallholder Supply Chains

Sergio Camelo, Stanford University, Stanford, CA, United States, camelo@stanford.edu, Dan Andrei Iancu, Joann de Zegher

We study the logistics surrounding pick-ups and deliveries of palm fruit in the Indonesian smallholder palm oil supply chain. Using data from smallholder farmers and transport providers from our field site in Sumatra, we reconstruct current transportation routes, and propose novel algorithms that rely on spatial or temporal optimization. We find that centralized vehicle routing algorithms can improve the transportation distances by 25%, and reduce the number of days that middlemen have to work by 30%. We expect the implementation of our results to reduce overall costs in the market, and ease the digitization of agricultural data in smallholder palm oil supply chains.

2 - To Bribe or not to Bribe in a Procurement Auction under Disparate Corruption Pressure

Xiaoshuai Fan, Hong Kong University of Science and Technology, Kowloon, Hong Kong, xfanaf@connect.ust.hk, Ying-Ju Chen, Christopher S. Tang

We examine a (large) manufacturer's bribery decision arising from a procurement auction under ''disparate corruption pressure" when another (small) manufacturer is known to bribe the auctioneer for the right of first refusal. We discover that the large manufacturer should refuse to pay bribes at all times to prevent from leaking its cost information and intensifying competition. However, even when the large manufacturer is disadvantaged by the intermediary, we show that it can benefit from the corrupted auction process when the difference in production efficiency or the bribe is high so that the cost advantage derived from the right of first refusal dominates the information disadvantage.

3 - Where Should I Sell? Optimal Market Selection for Farmers in an Agricultural Network

Somya Singhvi, MIT, 235 Albany Street, Cambridge, MA, 02139, United States, ssinghvi@mit.edu, Retsef Levi, Yanchong Zheng

Farmers' selection of markets to sell their produce is limited due to logistical constraints and lack of access to price information in many developing countries. In this work, we collaborate with Digital Green-Loop, an app that pools farmers' produce, and transports it to the wholesale markets in Bihar, India. Using transaction data from the platform, we first predict prices and then solve a network optimization model that takes various operational constraints into account and maximize farmers' overall revenue. Finally, we implement a field experiment to test the model's effectiveness.

4 - Matching Supply and Demand for Renewable Energy: The Case of Smart Meters

Bhavani Shanker Uppari, Singapore Management University, Singapore, 178899, Singapore, bhavaniu@smu.edu.sg, Kashish Arora

A large proportion of world's electricity demand is going to be met by renewable sources in the next decade. This poses a huge operational challenge: balancing the highly variable renewable electricity supply and the (relatively more) static demand. Using data from a large scale experiment in London, we examine the effect of dynamic prices (pushed through smart meters) on the response of consumers' demand. We build a consumer-level structural model of pricing and electricity consumption. Using the resultant estimates, we evaluate the efficacy of various policies (e.g., different tariff schemes and capacity allocations across different power sources) in terms of matching supply with demand.

■ WA23

CC- Room 3A

Spatial Decision Analysis

Sponsored: Decision Analysis

Sponsored Session

Chair: Valentina Ferretti, London School of Economics and Political Science, London School of Economics and Political Science, London, United Kingdom

1 - Sustainability Assessment of Potential Areas for Deep Geothermal Energy Systems in Switzerland

Matteo Spada, Paul Scherrer Institut, OHSA/D19, Switzerland, matteo.spada@psi.ch, Marco Cinelli, Peter Burgherr

Within the Swiss Energy Strategy for 2050 one of the potential technologies expected to replace the current nuclear-related electricity production is Deep Geothermal Energy (DGE). DGE is a secure base-load renewable technology, however, its feasibility strongly depends on local conditions such as, for example, geological and social ones. This study presents a methodology to assess the sustainability of potential areas of interest for DGE in Switzerland. The proposed method is based on a Stochastic Multicriteria Acceptability Analysis (SMAA) applied to an outranking approach combining uncertain inputs of explicit (e.g., heat flux) and calculated (e.g., risk indicators) criteria.

2 - Geospatial Visualization of Stakeholder Preferences

Tobias Fasth, Public Health Agency of Sweden, Kista, Sweden, tobias.fasth@foi.se

Decision problems in public decision-making involve stakeholders with a diverse demographic background. The stakeholders naturally have differing and conflicting preferences regarding the alternatives under consideration. To aid a decision maker to explore the stakeholders' opinions, we present a web-based open source application, enabling a geospatial analysis of the stakeholders' preferences and conflicts.

3 - Affect or Preferences in Urban Planning Decision Analysis

Aron Larsson, Stockholm University, Stockholm, Sweden
Aron Larsson, Mid Sweden University, Sundsvall, Sweden

In our experience, decision analysis in urban planning typically involve rather loosely defined alternatives rendering elaborated techniques for preference elicitation hard to utilise. On the other hand, stakeholders typically have rather strong mindsets with respect to their affect towards different higher level alternatives. This leads to some intriguing opportunities, and problems, when aiming to interpret affect statements for decision analysis purposes to stimulate a rational and resource efficient planning process. We here present a couple of tested approaches in a Swedish context.

4 - Map- Based Choice Architecture for Scope Insensitivity

Valentina Ferretti, Politecnico of Milano and London School of Economics and Political Science, Via Sismonda 7, Milano, 10143, Italy, V.Ferretti@lse.ac.uk, Yesmean Luk

Scientific research has demonstrated that subjective values are highly sensitive to the presence or absence of a stimulus (i.e., a change from zero to some number), but are largely insensitive to further variations in scope. This phenomenon is known as scope insensitivity and is a cognitive bias with relevant implications for both policy making and management. This paper is part of an ongoing research program aiming to investigate the impacts associated to the use of geographical maps in spatial decision analysis. The talk will discuss a behavioral laboratory experiment on map-mediated willingness to pay for the remediation of certain environmental areas.

■ WA24

CC- Room 3B

Energy Technology, Climate Change, and Uncertainty

Sponsored: Decision Analysis

Sponsored Session

Chair: Erin Baker, Univ of Massachusetts-Amherst, Amherst, MA, 01003, United States

1 - Optimal Residential Battery Storage Operations Using Robust Data-driven Dynamic Programming

Benjamin D. Leibowicz, Assistant Professor, University of Texas-Austin, ETC 5.128D, 204 E. Dean Keeton St. C2200, Austin, TX, 78712-1591, United States, bleibowicz@utexas.edu, Nan Zhang, Grani A. Hanasusanto

We consider operating battery storage in a home with rooftop solar PV to minimize expected electricity costs under uncertain electricity usage, PV generation, and electricity prices. It is difficult to solve this dynamic program using standard techniques, and to estimate conditional distributions from sparse data. To overcome these challenges, we implement a data-driven dynamic programming (DDP) algorithm that uses historical data to generate empirical conditional distributions and approximate the cost-to-go function. Then, we formulate robust DDP (RDDP) algorithms that consider the worst-case expected cost over a set of conditional distributions centered at the empirical distribution.

2 - Uncertainty in the Future Cost of Wind Energy Leads to Uncertainty in Climate Change Mitigation

Franklyn Kanyako, University of Massachusetts, Amherst, 52 Blackberry Lane, Hadley, MA, 01002, United States

We assess under uncertainty in future cost of wind energy and climate policies the impact of wind energy on electricity generation and the abatement cost. The IPCC forecast that wind energy could provide 13-14 percent of electricity supply under median climate change mitigation scenario by 2050. Using a Monte Carlo simulation method with the global change integrated assessment model (GCAM), we investigate the distribution over the share of wind energy in electricity generation mix and the impact of wind energy on other electricity generation technologies under three policy scenarios. A scenario that limits global temperature rise to less than 1.5 degrees Celsius, RCP 2.6 scenario and a carbon tax.

3 - Implications of Foresight in Electricity Capacity Expansion Models

Maxwell Leonard Brown, National Renewable Energy Laboratory, Golden, CO, 80401, United States

Electricity capacity expansion models are typically myopic. The optimization algorithms employed largely consider current-year conditions (e.g., fuel prices, load, technology costs and performance, policies and regulations) with limited to no knowledge of expected future changes in conditions. In this work, I evaluate how different levels of foresight—myopic through perfect foresight—impact investment and retirement decision-making within the context of a capacity expansion model. Both the mechanics for making this scaling possible as well as the results for a wide range of policy and cost scenarios are presented.

4 - Effect of Accidents on Energy Technology Adoption

Robert Barron, Western New England University, Springfield, MA, 66047, United States, Mary Hill

Integrated assessment models often neglect the impact of accidents on energy technology adoption. However, energy accidents can be costly, and negative public opinion can create significant obstacles to energy deployment, as evidenced by the effects of Three Mile Island, Chernobyl, and Fukushima on nuclear power. We develop the Energy Accidents Cost and Constraint (EACC) model to quantify these effects. The EACC model characterizes the likelihood and severity of energy accidents, then estimates their cost and effect on public acceptance of energy technologies. Initial results indicate that energy accidents have a non-trivial impact on energy technology adoption.

WA25

CC- Room 401

Revenue Management, Pricing II

Contributed Session

Chair: Hao Su, University of Maryland-College Park, College Park, MD, 20743, United States

1 - Product and After-sale Maintenance Service Pricing Decisions in Arisk-averse Supply Chain

Azmat Ullah, Shanghai Jiao Tong University, Shanghai, China, azmatullah@sjtu.edu.cn, Jiang Wei

This paper focuses on a problem where the manufacturer sells a repairable product while an agent provides after-sale service under uncertain demand. Due to demand volatility, either manufacturer or agent or both the players are risk-averse toward their decisions. The goal of this paper is to design various after-sale service strategies where the optimal price of repair or maintenance contract for the agent whereas the optimal product price for the manufacturer are explicitly determined such that the utility of both players can be maximized. A numerical example is presented to further illustrate the results and related issues.

2 - Opaque Selling and Customer Mistrust

Vinaysingh Jaisingh Chawan, Indian Institute of Management Indore, Indore, India, vinaysingh@iimidr.ac.in

Opaque selling focuses on differences in customer's valuations for different variants of the product. Customers who buy the opaque product expect some discount over the full information product. Thus, their WTP depends upon their prior belief about the probability of each product variant being delivered. Here, we consider the case where one product variant is more likely to be delivered, and it is also the less preferred variant. In this case, customers are likely to develop mistrust about the seller's intentions if huge discount is not offered for opaque product. We analyze this case to find conditions where opaque selling will work in the face of customer mistrust.

3 - A Quality-based Choice Model for Vertical Differentiation with Reference-dependent Preferences

Wenhan Zhao, University of Science and Technology of China, HeFei, China, 1612094758@qq.com, Xiaoming Yan

In markets with heterogeneous consumers, the attractiveness of a product may be influenced by other products within a context. Motivated by the goals of managing reference-dependent preferences and product line design, we consider a quality-based choice model that takes into account how preferences for a product vary with alternatives to the context. We show that the firm has more incentives to change the variety and relative standing of its products. In particular, when the importance of unfavorable comparisons among products and fixed setup cost are relatively low, the firm may offer a variety of distinct products. Otherwise, the firm may give up discrimination among consumers.

4 - Optimal Sales Policies for a Virtual Assistant Platform

Wenjia Ba, Stanford, Stanford, CA, United States, wenjiaba@stanford.edu, Haim Mendelson, Mingxi Zhu

We study the operating characteristics of a sales platform that interacts with consumers through a virtual assistant. The platform decides which product to offer and at what price, seeking to maximize its expected profit. Consumers are impatient and rational, seeking to maximize expected utility given the information available. We solve for the equilibria and develop efficient algorithms for implementing the solution. We examine the effects of information asymmetry and study how incentive misalignment depends on the consumer's private valuations. We compare the performance to that of a traditional web interface, where multiple products are presented at a time.

5 - Digitization and Profitability

Yasushi Masuda, Keio University, Yokohama, Japan, yasushi.masuda@gmail.com, Seungjin Whang

Consider a monopolistic vendor facing a known demand curve. Digitization lowers the variable production cost. Can we conclude that digitization always improves the vendor's profitability? Not necessarily. The physical product vendor prepares the exact quantity of the product to sell. By contrast, the digital product vendor will have more, and infinitely more, "leftover" stock, thanks to the nature of the digital product. This may lead to the downward spiral of price for the digital product vendor. We develop an economic model to formally analyze the impact of digitization on the profitability to the vendor.

6 - Win the Buy Box: Product Characteristics and Reselling-or-marketplace Choice

Hao Su, University of Maryland-College Park, College Park, MD, United States, haosu@rhsmith.umd.edu, Laharish Guntuka, Martin E. Dresner

This paper will determine product characteristics that predict a third-party seller's decision to sell a product through a marketplace (or a marketplace operator's decision to directly sell a product). We will empirically analyze the product-level data scraped from one of the largest online marketplaces in the U.S. for the purpose of this study. Our findings will provide implications to third-party sellers seeking to avoid direct competition with the marketplace operator.

WA26

CC- Room 4C-1

Healthcare service

Contributed Session

Chair: Sait Tunc, The University of Chicago Booth School of Business, Chicago, IL, 60615, United States

1 - Monitoring Length of Stay Through Control Charts: a Comparative Study of Diabetic Patients

Nasibeh Azadeh Fard, Assistant Professor, Rochester Institute of Technology, Rochester, NY, United States, azadehfard@gmail.com, Fatma Pakdil, Afsun Ezel Esatoglu

Monitoring length of stay (LOS) can help medical decision-makers identify areas of potential improvements and improve resource management, which results in a better quality of care for patients. This study aims to monitor process performance at hospitals by implementing a statistical process control (SPC) approach on LOS. The study focuses on diabetic inpatients admitted to hospitals in two national healthcare systems, i.e., US and Turkey. I-MR charts were used to analyze the datasets and monitor the variations of LOS.

2 - Capacity Reservation of Nursing Homes in Elder-care Management

Caiyuan Xiong, University of Science and Technology of China, Hefei, China, wx123456@mail.ustc.edu.cn, Xiaobei Shen, Yugang Yu

We consider a periodic-review capacity allocation problem with multiple resources and two demand classes in a finite planning horizon consisting of T periods. We translate the complex optimization problem to a problem with only two decision variables and adopt the decomposition to derive optimal solutions. In numerical studies, the optimal algorithm in the basic model is used as a heuristic to chech its robustness.

3 - Expanding the Donor Pool: Incentivizing the Use of Marginal Organs for Transplantation

Sait Tunc, University of Chicago Booth School of Business, Chicago, IL, United States, sait.tunc@chicagobooth.edu, Burhaneddin Sandikci, Bekir Tanriover

Transplantation emerged as the standard treatment for organ failure. Despite the growing shortage for donor organs as demand outpaces supply, a significant fraction of organs harvested for transplantation are rejected and discarded. We study the problem of organ wastage in a queueing-theoretic framework. We investigate socially efficient and equilibrium utilizations of donor organs, and discuss an incentive mechanisms that help increase the utilization of organs while also improving social welfare.

4 - Wafer Defect Inspection Optimization: Models, Analysis and Algorithms

Siyang Gao, Assistant Professor, City University of Hong Kong, Kowloon, Hong Kong, siyangao@cityu.edu.hk, Zhongshun Shi, Ming Qin, Weiwei Chen, Leyuan Shi

We consider the defect inspection optimization problem (DIOP) in this research. We formulate it as a mixed integer linear programming (MILP) model, and enhance the formulation using variable reduction. To address the computational challenge of solving large-scale DIOP instances, we further propose three approximation methods with theoretical bounds, namely, a constant-factor approximation algorithm that provides heuristic solutions quickly, a polynomial-time approximation scheme (PTAS) that has a strong performance guarantee, and an MILP-based hybridmethod that combines the PTAS framework and MILP formulation and is suitable for parallel computing by design.

■ WA27

CC- Room 4C-2

Joint Session Serv Sci/Practice Curated: Empirical Research in Service Management

Sponsored: Service Science

Sponsored Session

Chair: Simin Li, Kellogg School of Management, Northwestern University, Evanston, IL, 60208, United States

Chair: Nil Karacaoglu, Evanston, IL, 60201, United States

1 - Improving Customer Compatibility with Operational Transparency

MoonSoo Choi, Harvard Business School, Boston, MA, 02215, United States, mochoi@hbs.edu, Ryan Buell

Recent research has demonstrated the impact of customer compatibility - the degree of fit between the needs of customers and the capabilities of the operations serving them - on service performance. Companies with more compatible customers receive higher satisfaction scores and exhibit faster growth. However, when marketing their offerings to prospective customers, companies often shroud the operational tradeoffs inherent in their offerings in favor of emphasizing their advantages. Through a large-scale field experiment with a nationwide retail bank, we investigate how providing prospective customers with transparency into an operation's tradeoffs affects acquisition and engagement.

2 - Impact of Food Delivery Platforms on Traditional Restaurants: An Empirical Analysis

Varun Karamshetty, INSEAD, Boulevard de Constance, Singapore, 77300, Singapore, Varun.Karamshetty@insead.edu, Michael Freeman, Sameer Hasija

Online food delivery platforms (e.g. UberEats, GrubHub) represent a growing segment of the on-demand economy. As popularity of these platforms increases among consumers, restaurants are depending more on these channels to drive top-line growth. We empirically investigate the impact of such platforms on operational performance of traditional restaurants. We find, for example, that as the share of demand from 3rd party delivery platforms increases, overall demand becomes harder to forecast which leads to restaurants making sub-optimal labor scheduling decisions, increasing their labor costs.

3 - Gender Difference and Inequality in Leadership: Evidence from a Sport Retailing Chain

Susan F. Lu, Purdue University, Krannert 441, West Lafayette, IN, 47907, United States, lu428@purdue.edu, Ruoran Chen, Simin Huang, Lauren Xiaoyuan Lu

Using the data from a store retailing chain, we find that male managers are associated with better store performance. The gender differences are not caused by gender capability but mainly caused by the gender bias in store assignment: male managers are more likely to be assigned to good stores with high capability in sales.

■ WA28

CC- Room 4C-3

Trust Issues in E-Commerce/Business

Sponsored: Service Science

Sponsored Session

Chair: Cong Cao, University of Wollongong, Wollongong, NSW 2500, Australia

1 - understanding User Ads-click Intention in the Mobile Social Platform: the Mediation Effect of Trust and Moderation Effect of Prior Experience

Zhen Shao, Doctor of Philosophy, Harbin Institute of Technology, Harbin, 150006, China, shaozhen@hit.edu.cn, Zhengyuan Pan, Rui Zhao, Lin Zhang

This study developed a theoretical model to examine the mediation effects of cognitive vs. affective trust between dual routes and users' ads-click intentions in the mobile social platform. Particularly, user's prior experience was incorporated in the model to examine its moderating effect. A scenario-based survey was conducted in China and empirical results suggested that content personalization and vendor reputation were positively associated with cognitive trust, and their influences were stronger for users with prior experience. While social recommendation was positively related with affective trust, and its impact was higher for users without prior experience.

2 - Trust and Privacy Concern in the Digital Age: A Meta-analysis

Yeolib Kim, Ulsan National Institute of Science and Technology, UNIST, Ulsan, Korea, Republic of, yeolib.kim@unist.ac.kr

In this study, a meta-analysis of the relationship between trust and privacy concern in an information systems context was conducted. Overall, trust and privacy concern have a modest negative relationship. However, this relationship is idiosyncratic (significant heterogeneity) and certain moderators (e.g., privacy concern scale, sample type) were able to explain some of this variance.

3 - An Investigation of Cultural Proximity Between Hosts and Clients on Sharing Economy Driven Accommodation Platforms

Jianshan Sun, Doctor of Philosophy, Hefei University of Technology, Hefei, 230011, China, 2014800051@hfut.edu.cn, Shixuan Fu, Yezheng Liu, Yuanchun Jiang, Xiayu Chen, Chunli Liu, Chunhua Sun, Le Wu

Sharing economy driven accommodation platforms (SEDAP) are widespread for lodge reservations, however, still face the risk of privacy and ethical concerns. Trust is an important in the sharing economy driven peer-to-peer transactions to mitigate potential risks. Existing research fails to study the antecedents of trust from the interaction role of both hosts and clients. Taking SEDAP as our research context, we investigate whether cultural proximity between hosts and clients influences interpersonal trust, and how it relates to occupancy rate. Data from Airbnb.com were used to answer the research questions.

4 - The Role of Trust in the Sharing Economy: Analysis & Simulations of an AirBnB Market

Eyal Ert, Doctor of Philosophy, The Hebrew University of Jerusalem, Rehovot, 76100, Israel, eyal.ert@mail.huji.ac.il, Aliza Fleischer

In markets like Airbnb consumers face many attributes, including property, spatial (neighborhood), and seller (trustworthiness) attributes. Some are straight forward (e.g. price), others are inferred from images (e.g. trustworthiness) or text (self-disclosure-text). Yet there is no full market analysis on Airbnb that addresses the role of these attributes. Here we analyze Airbnb Stockholm market, using an aggregate nested logit equilibrium model with product differentiation. Our results indicate that the host's virtual attributes play an important role in this market as much as the property and spatial attributes. The seller's trustworthiness is as important as the location of the property

5 - Trust Creation in Online Chat

Xin Xu, Prof., The Hong Kong Polytechnic University, Hong Kong, xin.xu@polyu.edu.hk, Katherine Feng, Michael Mei

Online chat supported by both the Live Chat technology and recently the Chatbot technology is gaining significant popularity in E-Commerce. Online chat is not only the important channel for an e-commerce brand to answer ad hoc inquiries from customers, but also lays the foundation for creating trust between potential customers and the brand. In this research-in-progress, we propose a structure for online conversation analytics and examine the impacts of a number of key features of online chat on trust creation. We provide preliminary evidence supporting both the theoretical and the practical significance of online chat to trust creation in e-commerce.

6 - Evaluating the Helpfulness of Online Consumer Reviews in Social Networking Service Environment

Cong Cao, Tutor, University of Wollongong, Wollongong, NSW 2500, Australia, cong.cao@outlook.com, Jun Yan, Mengxiang Li

Given that Online Consumer Review (OCR) can effectively influence consumers' trust behavior and further the product sales, especially the booming social networking service (SNS), allow for consumers' sharing of review information in the vast social network beyond the limitation of time and space. Therefore, it is essential to understand the influence and mechanism of action of OCR and facilitate the widespread sharing in SNS. This research examines five types of essential factors that influence the helpfulness of OCR in SNS, namely the trustworthiness reflected by information publishers and the accuracy, completeness, currency and format of information perceived by information recipients.

■ WA29

CC- Room 4C-4

Information Design in Markets

Sponsored: Auction and Market Design

Sponsored Session

Chair: Rachel Cummings, Georgia Tech, Atlanta, GA, 30332-0205, United States

1 - Algorithmic Price Discrimination

Rachel Cummings, Georgia Tech, Atlanta, GA, 30332-0205, United States, Nikhil Devanur, Zhiyi Huang, Xiangning Wang

We study the third degree price discrimination problem, where an intermediary between a buyer and a seller can design market segments to maximize any linear combination of consumer surplus and revenue, but the intermediary is only partially informed. We consider three informational models. First, we assume that the intermediary has a Bayesian prior of the buyer's value. Second, we consider the sample complexity model, where the intermediary only sees samples from this distribution. Finally, we consider an online learning model, where the intermediary only sees past purchase decisions of the buyer, not her value. For each model, we present algorithms to compute near optimal market segmentation.

2 - Algorithms for Multi-agent Persuasion with No Externalities

Haifeng Xu, University of Virginia, Charlottesville, VA, United States, hx4ad@virginia.edu, Shaddin Dughmi

We study the algorithmics of information structure design — a.k.a. persuasion or signaling — in a fundamental special case introduced by Arieli and Babichenko: multiple agents, binary actions, and no inter-agent externalities. We focus on two basic signaling models, i.e., public and private persuasion, and for each we design efficient algorithms that match complexity lower bounds. Our results reveal insights regarding when public or private persuasion is tractable and are built upon useful characterizations of the optimal signaling scheme which may be of independent interests. Based on joint work with Shaddin Dughmi.

3 - Disclosure and Pricing of Attributes

Alex Smolin, Toulouse School of Economics, Toulouse, 06511, France, alexey.v.smolin@gmail.com

A monopolist sells an object characterized by multiple attributes. A buyer is privately informed about his tastes and uncertain about the attributes. The seller can disclose attribute information to the buyer in a form of a statistical experiment. The seller maximizes revenue and offers a menu of options varying in upfront payments, experiments, and strike prices. I show that optimal experiments belong to a tractable class of linear disclosures and characterize optimal menus in various scenarios.

4 - Third-Party Data Providers Ruin Simple Mechanisms

Juba Ziani, Caltech, Pasadena, CA, 91106, United States, jziani@seas.upenn.edu, Yang Cai, Federico Echenique, Hu Fu, Katrina Ligett, Adam Wierman

We study mechanism design in the presence of a data provider. When no data provider is present, simple mechanisms achieve a constant fraction of the optimal revenue. We demonstrate that this is no longer true in the presence of a third party data provider. Even with a single seller, a single bidder, and a single item of uncertain type for sale, pricing each item-type separately and bundling all item-types under a single price can simultaneously be a logarithmic factor worse than the optimal revenue. Further, in the presence of a data provider, item-type partitioning mechanisms still cannot achieve within a $\log \log$ factor of the optimal revenue.

■ WA30

CC- Room 6A

Optimization, Network

Contributed Session

Chair: Saeid Rasti, North Dakota State University, West Fargo, ND, 58078, United States

1 - Distributed Optimization of an Energy Distribution Network During Network Failure Using Blockchain Technology

Dustin Clasby, Colorado State University-Pueblo, Pueblo, CO, United States, Ebisa Wollega

The purpose of this research is to explore the state of the art in electrical distribution network optimization, specifically using alternating direction method of multipliers (ADMM) over a blockchain network, and then extend this work to include optimization during network uncertainty, including network failure. A simulated electrical network has been developed with nodes represented on a test Ethereum blockchain network.

2 - Robust Network Interdiction Considering Capacity and Resource Consumption Uncertainties

Darshan Rajesh Chauhan, Graduate Research Assistant and PhD Candidate, Portland State University, Portland, OR, United States, drc9@pdx.edu, Avinash Unnikrishnan, Stephen Boyles

The setting of the network interdiction problem is as follows: the goal of the adversary is to maximize the flow of a commodity through the network, and the goal of the interdictor is to minimize the maximum flow through the network by destroying arcs subject to the available interdiction resource. Uncertainties in the arc capacities and arc interdiction resource consumption are considered using a robust optimization framework. The final formulation is a mixed-integer program (MIP) and is solved exactly using Gurobi. A Benders' Decomposition based heuristic initialized with capacity and resource consumption cuts using Lagrangian Relaxation achieves high-quality results in a fraction of time.

3 - Dynamic Identification Method of Multi-bottleneck in Multimode Regional Rail Transit Interdependent Network

Su Liu, Southwest Jiaotong University, Chengdu, China, cdliusu@my.swjtu.edu.cn, Chengshuang Yin, Lin Wang

Adopting line load and network bottlenecks efficiency matrix, a multi-bottleneck dynamic identification model of regional rail transit network in stages is proposed based on the dynamic multi-Bottleneck transmission characteristics. Quantitative description and prediction of Multimode Regional Rail Transit Interdependent Network bottleneck under disturbance environment are realized. The validity of the model is verified by the calculation based on Chengdu-Chongqing Multimode Regional Rail Transit Interdependent Network.

4 - Network Optimization for Broadcast Services in Software Defined Networking

Ali Sarabi, Arizona State University, Tempe, AZ, United States, asarabi1@asu.edu, Arash Sarabi

These days, with increasing demands for streaming and broadcasting on the Internet, network service providers have been challenged to maximize their services in terms of quantity and quality. Software-defined network (SDN) is a computing approach that facilitates network management and enables efficient network configuration. In this study, we present a multi-commodity capacitated network flow model and train a neural network to learn traffic characteristics and optimize the network throughput in less execution time.

5 - Studying Essentiality in Protein Interaction Networks Using Centrality Metrics

Saeid Rasti, North Dakota State University, West Fargo, ND, United States, saeid.rasti@ndsu.edu

In this work, we propose a set of new group centrality metrics and show their performance in estimating protein importance in protein-protein interaction networks. We derive the computational complexity for each of the newly proposed metrics. Then, we provide mixed integer programming formulations to solve the problems exactly; due to the computational complexity of the problem and the sheer size of practical applications, using a commercial solver with the formulations is not a viable option. Hence, we also propose a column generation approach to solve the problems introduced.

■ WA31

CC- Room 6B

Military DMSMS Applications

Sponsored: Military and Security

Sponsored Session

Chair: James Starling, University of Washington “

1 - Strategic DMSMS Management

Peter Sandborn, Professor, University of Maryland, College Park, MD, United States, sandborn@umd.edu

Reactive DMSMS mitigation focuses on minimizing the cost of resolving the unavailability of parts after it occurs. While reactive solutions always play a role in obsolescence management, a higher payoff is possible through strategic management approaches. Strategic management of DMSMS uses part availability data, logistics management inputs, technology forecasting, and business trending to enable strategic planning, life-cycle avoidance maximization, and business case development for the support of systems. The most common approach to DMSMS strategic management is Design Refresh Planning, which consists of choosing the best mix of reactive management approaches and design refreshes.

2 - A Bayesian Approach to Understanding System-level Obsolescence

Victoria Diaz, University of Washington, Seattle, WA, United States, Christina Mastrangelo

Understanding the risks associated to part obsolescence is imperative from both cost and logistical points of view. Questions in this field are usually concerned with the obsolescence risk of certain parts. Our research diverges from this approach by exploiting the structure of parts within a system in order to identify the impact of individual part obsolescence on the entire system.

3 - Optimization in Long Term Preventive Maintenance Planning for Military Aircraft

Sergio Rebouças, Technological Institute of Aeronautics, Sao Jose dos Campos, Brazil, reb@ita.br, Fernando Teixeira Abrahão

Aircraft maintenance activities have a significant impact on logistic costs. Currently, the preventive maintenance planning occurs only in medium to short-term horizon, which increases the potential for losses both in the fleet availability and logistic costs, either by the limited view provided by a restricted planning time horizon or by the solution found. This work proposes an optimization approach for long-term preventive maintenance plan for military aircraft, based on integer programming, in order to minimize logistics costs, in terms of downtime, therefore increasing the availability of the fleet. The model reached valuable savings in downtime compared to the conventional method.

4 - Modeling System Obsolescence via Simple Additive Bayesian Allocation Network Process

Tomi Adetunji, George Washington University, Washington, DC, United States

This work proposes a new application called the Simple Additive Bayesian Allocation Network Process (SABANP). SABANP uses a combination of Multi Criteria Decision-Making methodology and a Bayesian Belief Network to address the impacts of obsolescence on long-life systems. The results show that the application can address complex obsolescence decisions and enables the selection of the best system.

5 - Optimal Technology Refresh Strategies Using Infinite Horizon Optimization

James Starling, University of Washington, Seattle, WA, 98195, United States, jkstar@uw.edu, Christina Mastrangelo, Youngjun Choe

The research provides an application of strategic diminishing manufacturing sources and material shortages (DMSMS) management. For a strategic level decision, the question of when to schedule the first and successive technology refreshes is often difficult. Using an infinite horizon optimization model, this study identifies the optimal sequencing of technology refreshes taking into account various DMSMS associated costs. The optimal strategy can assist the DMSMS manager in scheduling successive technology refreshes.

■ WA32

CC- Room 6C

Semiconductor Industry and Manufacturing

Contributed Session

Chair: Deepak Pahwa, North Carolina State University, 3520 Ivy Commons Drive, # 101, Raleigh, NC, 27606, United States

1 - Wafer-to-order Allocation in Semiconductor Back-end Production

Jelle Adan, Nexperia, Nijmegen, Netherlands, jelle.adan@protonmail.com

This work addresses the allocation of wafer to customer orders prior to assembly in a semiconductor back-end production facility with the aim to minimize overproduction. This study is motivated by and tested at Nexperia's assembly and test facilities, but its potential applications extend to many manufacturers in the semiconductor industry. Current practice is compared to existing heuristics and a commercial optimization solver. Experiments with real-world data sets show that significant improvements can be achieved. Furthermore, data processing steps and heuristics are presented to make the ILP applicable to real-world applications.

2 - Cascaded Convolutional Neural Network for Wafer Bin Map Defect Pattern Classification

Sun Geu Chae, Hanyang University, Seoul, Korea, Republic of, sgchae@psm.hanyang.ac.kr, Suk Joo Bae

Defect patterns on wafer maps provide useful information for identifying causes of failures in semiconductor manufacturing process. Since defect patterns represent specific root causes of failure, identifying the defect pattern is important. Recently, due to advances in image classification using Convolutional Neural Networks (CNN), various works have been conducted on wafer map defect pattern classification using CNN. However, in training the neural networks model, hyperparameter and network designs may have unintended issues such as overfitting. To overcome these risks, end-to-end trainable cascaded convolutional neural networks comprised of two stages is proposed in this research.

3 - Incorporating Assembly Line Balancing into Assembly Line Feeding Decision Making

Nico André Schmid, Ghent University, Ghent, Belgium, nico.schmid@ugent.be, Benoit Montreuil, Veronique Limere

Often, assembly line planning is exclusively associated with balancing, i.e., the distribution of tasks among workers. However, products are becoming more complex due to customization and accumulating part variants. The assembly line feeding problem aims to support managing this complexity by determining part provision, e.g., whether parts are sequenced or supplied in bulk. However, feeding decisions affect picking times and thus operators' workloads. Hence, we integrate assembly line balancing and feeding to minimize overall costs by means of a MIP model while maintaining a highly productive assembly system. Our findings are based on real world data from an automotive company.

4 - Order Acceptance Planning Using Markov Decision Process and Reinforcement Learning

Amirhosein Gholami, Binghamton University, Binghamton, NY, United States, Nasim Nezamoddini

The modern dynamic markets face a high level of variations in products and services. To sustain businesses in this highly volatile environment, supply chains should increase their flexibility by adopting make to order (MTO) systems for customized products. This research presents an application of Markov Decision Process (MDP) and Reinforcement Learning (RL) for optimizing order acceptance decisions in MTO supply chain systems. The technique is implemented on a 3-tiers supply chain. The efficiency of the technique is investigated by simulating different scenarios and risk analysis using statistical techniques.

5 - Using Deep Reinforcement Learning for Order Allocation in a Manufacturing-as-a-service Marketplace

Deepak Pahwa, North Carolina State University, Raleigh, NC, United States, dpahwa@ncsu.edu, Binil Starly

A two-sided manufacturing-as-a-service marketplace is a dynamic platform where orders and supplier capacities arrive stochastically over time. The platform needs to make two key decisions for optimal order allocation: how to allocate i.e. which orders to allocate to which suppliers and when to allocate i.e. how long the platform should wait to thicken the market before allocating. Reinforcement learning methods fail because of high dimensional state and action spaces. We use deep reinforcement learning (DRL) methods to estimate long term reward function for optimal order allocation. Our results prove the viability of DRL methods to solve this otherwise computationally intractable problem.

■ WA33

CC- Room 602

Reinforcement Learning for Combinatorial Optimization

Sponsored: Optimization/Computational Optimization and Software

Sponsored Session

1 - Reinforcement Learning for Online Stochastic Optimization Problems

Anna Luo, Applied Scientist, Amazon.com, Seattle, WA, United States, Bharath Balaji, Jordan Bell-Masterson, Enes Bilgin, Andreas Damianou, Arpit Jain, Alvaro Maggiar, Pablo Garcia Moreno, Murali Balakrishnan Narayanaswamy, Chun Ye

We show that many online stochastic optimization problems in OR where the distribution of data is unknown is amenable to RL approaches. In particular, we study online stochastic versions of three canonical OR problems with a wide range of practical applications: Bin Packing, Newsvendor, and Vehicle Routing. We apply both well-known OR approaches and newer RL algorithms to these problems and analyze results. For each of these problems, we find that RL is competitive with or superior to the OR baselines.

2 - Reinforcement Learning for Spare Part Inventory Management

Sayak Roychowdhury, Assistant Professor, IIT Kharagpur, Kharagpur, India, sayakroychowdhury@gmail.com, Sarada P. Sarmah

Spare parts inventory management is an essential operation in different industry sectors, e.g. manufacturing, mining etc. Very often, there are dependencies among spare parts, that need to be ordered together to be utilized at the times of maintenance. The demand of such parts at any time maybe dependent on the frequency of scheduled and unscheduled maintenance, and longevity of the parts concerned. Here we propose a reinforcement learning method to determine the optimal order quantity of such spare parts, considering uncertainty in demand, and varying degrees of dependency. This has the potential to reduce inventory and opportunity costs related to availability of spare parts.

3 - A Reinforcement Learning Approach for Assigning Multiple Trucks to Multiple Orders

Yuncheol Kang, Hongik University, Seoul, Korea, Republic of, Daiki Min

We formulate a sequential assignment problem that matches multiple trucks to incoming multiple orders in the on-demand parcel delivery environment. Such problem, however, is highly likely to be intractable due to lots of factors and underlying complex dynamics of the environment. To tackle with this problem, we utilize a reinforcement learning algorithm along with a function approximation approach to deal with huge size of sequential decision making problems. Numerical illustrations will be provided by comparing the suggested algorithm with other related algorithms.

4 - Solving a Multi-item Capacitated Lot-sizing Problem with Reinforcement Learning

Lotte van Hezewijk, PhD Candidate, Eindhoven University of Technology, Eindhoven, Netherlands, Tom Van Woensel, Nico P. Dellaert, Noud Gademann

We study a multi-item, single-stage capacitated lot-sizing problem with stochastic demand. In this problem, the model incurs set-up costs, holding costs, and backorder costs. The objective is to determine the production lot-sizes in every period such that the total costs are minimized. This problem typically suffers from the curse of dimensionality and requires advanced heuristics to find solutions. We model the problem as a Markov decision process and learn optimal policies using reinforcement learning. We compare the results of applying this machine learning technique to existing solution heuristics.

5 - Deep Reinforcement Learning Approach for Metro Train Scheduling with Stochastic Passenger Demand

Chengshuo Ying, City University of Hong Kong, Hong Kong SAR, Hong Kong, cying9-c@my.cityu.edu.hk, Andy H.F. Chow, Kwai-Sang Chin

This paper presents an optimization method for metro timetabling over a double-track line with stochastic passenger demand. The problem is decomposed into many decision stages according to operation dynamics. With the aims to minimize passenger waiting time and operational cost, a learning agent is developed to find the quasi-optimal solution which is represented as a sequence of operational actions. The agent is trained with deep deterministic policy gradient algorithm and a case study supported by practical demand profile shows that the developed method outperforms classical heuristic algorithms in term of solution quality, computation time, and robustness under demand uncertainty.

■ WA34

CC- Room 603

Optimization & Sustainability

Contributed Session

Chair: Maneesh Reddy Ajjuguttu, Clemson University, Clemson, SC, 29631, United States

1 - Portfolio Optimization-based Approach for Optimal Capacity Utilization Using Less-than-truckload Carrier-to-carrier Collaborations Based on Freight Capacity Options

Choungryeol Lee, Research Assistant, Purdue University, West Lafayette, IN, United States, lee1210@purdue.edu, Srinivas Peeta

This study proposes a mean-risk portfolio optimization-based approach for optimal capacity utilization in the less-than-truckload carrier-to-carrier collaboration market. The proposed approach allows each collaborating carrier to optimally allocate its own capacity and invest excess capacity by considering the trade-off between return and risk. Results from numerical experiments show that the proposed approach enables the collaborating carriers to minimize risk for a specified level of expected return so as to enhance capacity utilization, profitability, and serviceability.

2 - Residential Stormwater Management: Promoting the Installation of Green Infrastructure Through the Optimal Distribution of Incentives

John Edgar Fontecha Garcia, University at Buffalo, Buffalo, NY, United States, Zhenduo Zhu, Alexander Nikolaev, Jose Luis Walteros

Several cities across the US have launched incentives programs to catalyze the adoption of green infrastructure in private property; nonetheless, identifying the most efficient incentives (and the distribution policy) to persuade residents is still a challenge. To strategically allocate the available budget and maximize the common good, it is critical to consider the government goal as well as each household's individual decision-making process. To tackle this challenge, we propose the design and implementation of a bi-level optimization problem to model the interaction between the decisions of both players.

3 - Institutional Investors and Green House Gas (GHG) Emissions

Jaeseog Na, KAIST, Seoul, Korea, Republic of, jsna@kaist.ac.kr, Bowon Kim

We examine how institutional investors affect the GHG emission rate. Based on the U.S. firms' GHG data from Trucost, we find that the presence of institutional investor reduces the GHG. Also, we try to investigate the heterogeneous effects of institutional investors. It appears that both short-term and long-term oriented institutions have incentives to reduce GHG. The institutions with short-term investment horizon tend to avoid a penalty, and the institutions with long-term investment horizon have incentives to push managers toward engaging in more environmental activities. It implies that institutional monitoring generally has a positive effect on reducing GHG emissions.

4 - Can Interest Rate Marketization Alleviate the Financing Constraints of R&D Investment? Evidence from China

Xinxin Zhao, Huazhong University of Science and Technology, Wuhan, China, zhaoxx20@163.com

This paper aims to examine the moderating effect of interest rate marketization on the relationship of the financing constraints and R&D investments. The interest rate marketization index is constructed using the interest rate determination ways, the interest rate fluctuation restrictions and the real interest rate level. Based on panel data of Chinese listed firms for 2007-2017 in manufacturing industry, using Euler-equation investment model, we find that interest rate marketization alleviates the financing constraints especially for non-state-owned enterprises.

5 - Operational Transparency and Slow Fashion

Maneesh Reddy Ajjuguttu, Clemson University, Clemson, SC, United States, majjugu@g.clemson.edu, Aleda Roth

This study addresses the effects of operational transparency on the fashion sector. In particular, we examine the consumer buyer behaviors on the emerging movement called "slow fashion." Slow fashion is a strategy that aims to reduce the toxic and non-toxic wastes that accrue through the supply chains, which are causing havoc to the environment.

■ WA35

CC- Room 604

OPT Interger/Global: New Relaxation Techniques for MINLPs

Sponsored: Optimization/Integer and Discrete Optimization

Sponsored Session

Chair: Taotao He, West Lafayette, IN, 47906, United States

1 - Optimization Problems Involving Matrix Multiplication with Applications

Burak Kocuk, Sabanci University, Istanbul, Turkey, burakkocuk@sabanciuniv.edu, Ali Rana Atilgan

We consider optimization problems which involve the multiplication of unknown matrices to be selected from a given finite family. Such nonlinear discrete optimization problems arise in applications from biology and material science among others, and are known to be NP-Hard even for a special case of interest. We propose compact-size mixed-integer programming formulations for these problems utilizing disjunctive arguments. Finally, we present the results of our computational experiments.

2 - Enhancing Relaxations for Nonconvex Mixed-integer Quadratically Constrained Quadratic Programs

Carlos Nohra, Carnegie Mellon University, Pittsburgh, PA, United States, cnohrakh@andrew.cmu.edu, Aida Khajavirad, Nick Sahinidis

This work addresses the global optimization of nonconvex mixed-integer quadratically constrained quadratic programs. We show how certain facets of the Boolean Quadric Polytope can be utilized in order to enhance factorable relaxations of MIQCQPs constructed by global optimization solvers. To illustrate the benefits of this approach, we propose an efficient implementation which integrates these facets as cutting planes into the branch-and-reduce global solver BARON. We demonstrate the impact of the proposed implementation by conducting an extensive computational study on a large collection of problems selected from publicly available test sets.

3 - Tight Piecewise Polyhedral Relaxations for MINLPs with Multilinear Intermediates

Harsha Nagarajan, Los Alamos National Laboratory, Los Alamos, NM, 87544, United States, harsha@lanl.gov

We present a MILP-based formulation of a piecewise, polyhedral relaxation of multilinear terms based on term-wise convex hull representations. We also present valid inequalities which tighten these relaxations for the summation of multilinear terms in a given constraint. Further, we present an adaptive discretization-based algorithm which efficiently solves MINLPs to global optimality. Finally, we present computational results showing the effectiveness of our formulation on various MINLPLib instances.

4 - Fractional 0-1 Programs: Links Between Mixed-integer Linear and Conic Quadratic Formulations

Andres Gomez, University of Pittsburgh, Pittsburgh, PA, 15217, United States, agomez@pitt.edu, Erfan Mehmanchi, Oleg A. Prokopyev

We focus on methods that improve the performance of solution approaches for multiple-ratio fractional 0-1 programs (FPs) in their general structure. In particular, we explore the links between equivalent mixed-integer linear programming and conic quadratic programming reformulations of FPs. Thereby, we show that integrating the ideas behind these two types of reformulations of FPs allows us to push further the limits of the current state-of-the-art results and tackle larger-size problems. We perform extensive computational experiments to compare the proposed approaches against the current reformulations from the literature.

■ WA36

CC- Room 605

Robust Optimization with Varying Uncertainty

Sponsored: Optimization/Optimization Under Uncertainty

Sponsored Session

Chair: Kartikey Sharma, Northwestern University, Evanston, IL, 60208, United States

Chair: Omid Nohadani, Northwestern University, Northwestern University, Evanston, IL, 60208-3119, United States

1 - A Generalized Cutting Plane Algorithm for Robust Optimization with Decision-dependent Uncertainty Sets

Anirudh Subramanyam, Argonne National Laboratory, Lemont, IL, United States, Nikolaos Lappas, Chrysanthos Gounaris

There exist many optimization problems in which the decision-maker can affect the realization of the uncertain parameters (also known as endogenous uncertainty). Such settings can be addressed within the context of a robust optimization framework via the use of decision-dependent uncertainty sets. To that end, we propose a primal branch-and-bound algorithm that generalizes the well-known cutting plane method of Mutapcic and Boyd to the case of decision-dependent uncertainty sets. A comprehensive computational study showcases the advantages of the proposed algorithm over that of existing methods that rely on classical duality-based reformulations.

2 - Unit Commitment with Decision Dependent Uncertainty

Kartikey Sharma, Northwestern University, Evanston, IL, United States, kartikeysharma2014@u.northwestern.edu, Omid Nohadani

Unit commitment problems are an important category the area of Electricity production and distribution. When solving these problems we have to account for uncertainty in demand and generation. In this work we consider the UC problem under decision dependent uncertainty where the demand uncertainty can be affected by decisions for a price. We leverage an affine policy and provide a cut generation algorithm to solve this problem. We evaluate the performance of this model through numerical experiments.

3 - Optimization under Decision Dependent Uncertainty

Omid Nohadani, Northwestern University, Evanston, IL, 60208-3119, United States, nohadani@northwestern.edu, Kartikey Sharma

The efficacy of robust optimization spans a variety of settings with predetermined uncertainty sets. In many applications, uncertainties are affected by decisions and cannot be modeled with current frameworks. This talk takes a step towards generalizing robust optimization to problems with decision-dependent uncertainties, which we show are NP-complete. We introduce a class of uncertainty sets whose size depends on decisions, and proposed reformulations that improve upon alternative techniques. In addition, the proactive uncertainty control mitigates over conservatism of current approaches.

■ WA37

CC- Room 606

Recent Advances in Robust Optimization

Sponsored: Optimization/Optimization Under Uncertainty

Sponsored Session

Chair: Guanglin Xu, University of North Carolina at Charlotte, University of North Carolina at Charlotte, Charlotte, NC, 28223, United States

1 - Semi-parametric Choice Model: Implications and Applications

Xiaobo Li, Assistant Professor, National University of Singapore, Singapore, Singapore, iselix@nus.edu.sg

In this talk, we present the modeling power of the semi-parametric model, a recently proposed choice model that is derived based on the distributionally robust bound on consumers' welfare. We reformulate some existing choice models and study their practical implications due to these reformulations. Applications in revenue management problems are also studied.

2 - Zeroth- and First-Order Stochastic Methods for Large-Scale Distributionally Robust Optimization

Guanglin Xu, University of North Carolina at Charlotte, 9201 University City Blvd., Cameron Hall - 204, Charlotte, NC, 28223, United States, guanglin.xu@uncc.edu

We introduce efficient first- and zeroth-order methods to solve large-scale distributionally robust optimization problems. We propose stochastic gradient-based and alternating direction method of multipliers-based algorithms in the case where gradient information is known, and propose zeroth-order methods in the case where the gradient information is not available. To enhance the convergence, we incorporate a stochastic variance reduction technique in our methods. Finally, we prove theoretical guarantee of our proposed algorithms and validate their effectiveness through various numerical experiments.

3 - Robust Optimization with Order Statistic Uncertainty Set

Pengfei Zhang, The University of Texas at Austin, Austin, TX, 78703, United States, Diwakar Gupta

We propose a new uncertainty set based on order statistics for robust optimization problems. We develop a tractable formulation of the robust optimization model with our new uncertainty set. We highlight the advantages of the new uncertainty set, and show that the interval uncertainty set, the budget uncertainty set and the demand uncertainty set can be obtained as special cases of the new uncertainty set. Finally, we report computational results on portfolio optimization problems with shortfall constraints, and show that the new uncertainty set has superior performance relative to common alternatives.

■ WA38

CC- Room 607

Optimization, Stochastic I

Contributed Session

Chair: Minseok Ryu, University of Michigan, Ann Arbor, MI, 48105, United States

1 - Two Stages Stochastic Programming for Multi-echelon Multi-product Reverse Logistics Network Design with Lot Sizing

Vahid Azizi, Iowa State University, Ames, IA, United States, Guiping Hu

This study proposes an integrated model for a multi-period multi-product reverse logistics network design problem under uncertainty. The stochastic reverse logistics network is modeled as a two-stage stochastic program to make strategic and tactical decisions. The main uncertain parameters are the primary market return and secondary market demand. The model aims to determine the optimal number of sorting centers and warehouses, optimal lot sizes and optimal transportation plan that minimizes expected total system cost over the planning horizon. A case study has been conducted to validate the model. Numerical results are analyzed to illustrate the usefulness of the stochastic model.

2 - Modeling Lot-sizing and Cutting Stock Problem with Uncertain Material Batch Sizes

Hsueh-Chien Peng, National Chiao Tung University, Hsinchu, Taiwan, hcpeng.iem07g@nctu.edu.tw, Sheng-I Chen

This study considers the restrictions of equipment capacity and material availabilities for making production planning. Raw materials are received in batches, and each of them has uncertain quantity and can be used to fulfill orders with the same specifications. The decision is to satisfy demands with the objective to minimize the WIP levels, as well as excess supplies. To tackle the problem, we integrate capacitated lot-sizing and cutting-stock models with the development of stochastic mixed integer program to capture the uncertain batch size of materials. Sensitivity analysis is performed to assess the uncertain effect on productivity and loading for bottleneck stations.

3- Sample Efficient Q Learning for Generator Expansion Planning

Vijay Kumar, Pennsylvania State University, State College, PA, United States, vuk19@psu.edu, Mort Webster

The long-term Generator Expansion planning problem is a multi-stage decision to determine the optimal type, size, location and timing of new power plants to minimize the entire cost over the horizon. The conventional methodology of dynamic programming suffers from the curse of dimensionality and is computationally intractable. We propose a novel sampling algorithm, inspired from importance sampling for Multi-Stage Generator Expansion planning, under uncertainties in fuel and carbon prices.

4 - Stochastic Transmission Expansion Planning Using Randomization Policy

Minseok Ryu, University of Michigan, Ann Arbor, MI, United States, msryu@umich.edu, Ruiwei Jiang

We consider a stochastic transmission expansion planning (STEP) model that optimally expands a transmission grid to ensure reliable operations under uncertain input parameters. The STEP models are computationally challenging due to the binary recourse variables representing the number and location of the new circuits. In this talk, we propose a randomization policy to mitigate this challenge and provide an upper bound of the optimal value of STEP. We test the proposed solution approach in several numerical case studies.

■ WA39

CC- Room 608

Heuristic Programming and Traffic Management

Contributed Session

Chair: Yassine Ridouane, Georgia Institue of Technology, Atlanta, GA, 30318, United States

1 - Information Management under Strategic Inventory in Dual Channel Supply Chain

Jingjie Su, University of Texas at Arlington, Arlington, TX, United States, jingjie.su@mavs.uta.edu, Yan Lang, Kay-Yut Chen

We study the dual channel supply chain model with strategic inventory. The retailer gain advantage by using the strategic inventory. On the other hand, we also study if the asymmetric information will provide retailer with further advantage. We apply the game theory model and find the PBNE equilibrium of the model.

2 - A Substitution Based Model for Equipment Balancing Problem in Service Networks

Yassine Ridouane, Georgia Institute of Technology, Atlanta, GA, United States, yridouane@gatech.edu, Yu Yang, Natashia Boland, Alan Erera, Martin W. P. Savelsbergh

Logistics companies often operate a heterogeneous fleet of equipment to support their network operations. This poses a challenge as facilities need to be balanced with respect to total inbound and outbound equipment flows within a tactical planning horizon. We formulate an equipment balancing MIP model in which we seek to minimize the equipment imbalance by substituting the initial equipment assigned to a load with a compatible one. In a second phase, we seek to minimize the number of substitutions required. This problem can be proven to be NP-Hard. Computational experiments using realistic instances show that a significant reduction in the total equipment imbalance in the network can be obtained.

3 - Designing Locations and Capacities for Charging Stations to Support Intercity Travel of Electric Vehicles

wang chengzhang, Tsinghua university, Beijing, China, 875083229@qq.com

This study is devoted to designing locations and capacities of charging stations for supporting long-distance travel by electric vehicles. We first establish an expanded network structure to model the set of valid charging strategies for EV drivers, and then a variational inequality is formulated to capture the equilibrated route-choice and charging behaviors of EVs. Next, we formulate the problem of designing the locations and capacities of charging facilities under a fixed budget constraint and solve the optimization problem with a heuristic algorithm. Numerical examples with a toy network and a highway network are used to show the effectiveness of the proposed methodology.

■ WA40

CC- Room 609

Optimization, Nonlinear Programming

Contributed Session

Chair: Dimitri Papadimitriou, U Antwerpen, 24 rue du Charme, Brussels, 1190, Belgium

1 - Discrete Moment Problems with Log-concave and Log-convex Distributions

Talal Alharbi, PhD Student, Florida Institute of Technology, Melbourne, FL, United States, talharbi2015@my.fit.edu, Anh Tuan Ninh, Ersoy Subasi, Munevver Mine Subasi

We introduce new shape constraints (log-concavity and log-convexity) to discrete moment problems (DMP) for bounding the r-out-of-n type probabilities and expectations of discrete random variables with non-negative support. Numerical experiments show significant improvement in the tightness of the bounds. The proposed problem is expected to expand the scope of applications for both discrete moment problems and log-concavity and log-convexity.

2 - A Real-Time Optimization Scheme for Multi-Period AC Optimal Power Flow Problems

Youngdae Kim, Postdoctoral appointee, Argonne National Laboratory, Lemont, IL, United States, Mihai Anitescu

We present a real-time optimization strategy for a rolling horizon method applied to multi-period AC optimal power flow problems (MPACOPFs), where each of temporally interlinked MPACOPFs needs to be solved in every few minutes. An approximate tracking scheme combined with two warm-start methods will be described. Our method shows fast computation time while maintaining a good solution quality, which makes it best suitable to work under a real-time environment. Theoretical results bounding the tracking error to the second order of the parameter changes will be presented.

3 - A Direct Search Algorithm for Multi-objective Optimization in MATLAB

Adam Hug, The MathWorks, Natick, MA, United States

MATLAB's Global Optimization Toolbox now offers the paretosearch function: a direct search method that is designed to solve black box multi-objective problems. The algorithm uses an infinite barrier method and a direct search framework to obtain a set of Pareto optimal solutions. Coupled with this approach are several heuristics aimed at producing a wide sampling of the Pareto front. We will give an overview of the algorithm and discuss how it compares to metaheuristic approaches.

4 - Two Modified Trust Region Algorithms for Unconstrained Optimization

Mostafa Rezapour, PhD candidate, Washington State University, Pullman, WA, United States, mostafa.rezapour@wsu.edu, Thomas J. Asaki

We propose two modified trust-region algorithms for unconstrained optimization. These algorithms minimize a model of the objective function within the trust-region. Our modified algorithms are opportunistic in the sense that they explore outside of the trust-region if the boundary of the region prevents the algorithm to accept a more beneficial point. It occurs when there is very good agreement between the model and the objective function on the trust-region boundary, and we can find a step outside the trust-region with smaller value of the model objective while the agreement between the model and the objective function remains good.

5 - Robust Optimization of Machine Learning Models

Dimitri Papadimitriou, U. Antwerpen, Brussels, Belgium, dimitri.papadimitriou@uantwerpen.be

Please check the mobile app for this abstract.

■ WA41

CC- Room 610

Strategies in Supply Chain Network

Sponsored: Optimization/Network Optimization

Sponsored Session

Chair: Kedong Chen, University of Minnesota

1 - Identifying the Locus of Vulnerability to Supply Network Disruption

Hyunwoo Park, The Ohio State University, Columbus, OH, 43210, United States, park.2706@osu.edu, Yusoon Kim

We propose measures for node vulnerability in supply networks and compare their explanatory power in network-level disruptions using empirically observed supply networks. We also extend the notion of network-level disruptions incorporating multi-source multi-sink situations in supply networks. We discuss the implications of our study for managing managerial attention to monitor disruptions in supply networks.

2 - Distributionally Robust Inventory Network

Yun Zhang, Carnegie Mellon University, Pittsburgh, PA, 02139, United States, pyzhang@cmu.edu, Louis L. Chen

We consider a network version of newsvendor model. In period one, the network planner decides on the quantity of inventory to be placed at each node. In period two, demand materializes, the planner decides on allocation. Demand follows an adversarially chosen distribution from an ambiguity set, consisting of all joint demand distributions consistent with a set of marginal distributions. Via modern tools in discrete convex analysis, we precisely characterize the optimal inventory and allocation decisions. More interestingly, we are able to characterize the worst-case demand distributions. This allows us to provide managerial insights into the impact of network topology on inventory strategies.

3 - Supply Network Resilience Learning a Data-driven Exploratory Study

Yuhong Li, Old Dominion University, Norfolk, VA, 48084, United States, y9li@odu.edu, Kedong Chen, Kevin W. Linderman

When a disruption occurs, individual firms can learn from the disruption and reduce the risk of similar future disruptions, but what happens to the supply network? This study examines how the supply network learns from suppliers' disruptions to improve network resilience. It takes an agent-based perspective where suppliers act as agents within an ego network of a focal firm. Analytical analysis and data analytics are conducted to understand the condition under which supply network resilience learning improves more. Risk plays a contingent role in the cross-level learning effect. Data-driven propositions aim to make the most of limited resources and better facilitate supply network learning.

4 - Effect of Social Influencer on Crowdfunding Project Efficiency

Hung-Chung Su, University of Michigan-Dearborn, Dearborn, MI, 48126, United States, hcsu@umich.edu, Shih-Hui (Steven) Hsiao, Ta-Wei Kao, Chih-Hao Ku

Existing crowdfunding studies pay much attention to the influence of properties of the project (e.g., category and goal; the information content of the project) on crowdfunding success. In this project, we collect project creators' network data from Kickstarter and apply stochastic frontier analysis to understand how creators' network characteristics affect their project crowdfunding efficiency, the transformation of project inputs (properties) to output (the amount of funding). Our initial findings show that the backer's network centrality significantly influences crowdfunding efficiency.

■ WA42

CC- Room 611

Network Optimization for Resilience

Sponsored: Optimization/Network Optimization

Sponsored Session

Chair: Charles D. Nicholson, University of Oklahoma, Norman, OK, 73019, United States

1 - Community Resilience Analysis: Joplin, MO

Charles Nicholson, University of Oklahoma, Norman, OK, 73019, United States, cnicholson@ou.edu

Communities, such as cities and towns, are highly dependent on the built environment, including the building portfolio and the infrastructure networks (e.g., transportation, power, water), as well as existing social and economic networks and systems. This interdependent system of systems is, however, vulnerable to natural hazards. In May 2011, a catastrophic EF5 multiple-vortex tornado struck the community of Joplin, Missouri killing more than 150 people and causing billions of dollars in damage. In this presentation, we present a case study based on Joplin and the 2011 tornado to analyze issues, opportunities, and challenges for community resilience optimization.

2 - Facility Location and Restoration Games

Suzan Iloglu, Yale University, New Haven, CT, United States, Laura Albert, Carla Michini

We present a non-cooperative facility location and restoration game that considers infrastructure systems as a layered network with each system as a layer of the network. Players, infrastructure owners, locate facilities within their layer, and install edges within their own layer and between the layers to minimize the cost to satisfy their own demand. We prove the existence of Nash equilibria. We propose a mechanism using inverse optimization and an approximation primal-dual algorithm to decide fees that players should pay when sharing facilities to obtain the social optimal solution.

3 - An Approximate Dynamic Programming Approach for the Stochastic Two-level Integrated Inventory Problem: Applications in Battery Swap Stations

Amin Asadi, University of Arkansas, Fayetteville, AR, United States, asadi@email.uark.edu, Sarah Nurre

We present the class of stochastic two-level integrated inventory problems (TOLIPs) which we use to determine policies for the management of inventory at EV and drone battery swap stations. In a stochastic TOLIP, the use and replenishment of first-level battery charge is the direct cause of degradation in second-level battery capacity. Thus, when faced with uncertain demand for battery swaps, we determine policies for charging and discharging battery charge inventory and replacing battery capacity inventory over time. We model the stochastic TOLIP as a Markov Decision Process. Using approximate dynamic programming, we determine policies and deduce insights for the swap station application.

4 - Approximating Optimal Recovery of Infrastructure Networks via Distributed Percolation Processes

Bowen Fu, PhD Candidate, Rice University, Houston, TX, United States, Leonardo Duenas-Osorio

Optimization methods guarantee the optimality of network resilience under practical resource constraints, but become computationally intractable for realistic systems. In this talk, we propose a scalable method based on percolation theory that exploits the modularity of networks and embeds field-informed restoration processes, to approximate optimal repair sequences for resilience. Our approximations ensure low computational cost and acceptable accuracy as ongoing theoretical developments suggest. We show the merits of our proposed strategy to support community resilience by comparing against guaranteed-optimality recovery sequences for realistic utility networks.

5 - Interdependent Integrated Network Design and Scheduling Problems with Machine Movement: Application Post Disaster Infrastructure Restoration

Aniela Garay-Sianca, University of Arkansas, Fayetteville, AR, United States, Sarah G. Nurre Pinkley

Recent disasters have motivated many researchers to focus on post disasters infrastructure restoration models. Many of these models fail to account for infrastructure interdependency on the availability of the transportation network. We propose a new mixed integer optimization model that considers restoration interdependency among infrastructures, network optimization, and scheduling. We include the selection of damaged components, the assignment of these components to work crews, the sequence of the restoration, and the movement of work crews on the transportation network. We provide significant results and comparison with a current integrated network design and scheduling model.

■ WA43

CC- Room 612

Joint Session MCDM/ICS: New Research Directions in Multi-objective Integer Programming: Machine Learning and Multiplicative Programming

Sponsored: Computing

Sponsored Session

Chair: Hadi Charkhgard, University of South Florida, Tampa, FL, 33620-5350, United States

1 - A Criterion Space Search Algorithm for Mixed Integer Linear Maximum Multiplicative Programs: A Multi-objective Optimization Approach

Hadi Charkhgard, University of South Florida, Tampa, FL, 33620-5350, United States, Payman Ghasemi Saghand

We study a class of mixed integer optimization problems with linear constraints and a multi-linear objective function, the so-called mixed integer linear maximum multiplicative programs (MIL-MMPs). MIL-MMPs can also be viewed as special cases of the problem of optimization over the set of efficient solutions in multi-objective optimization. By using this observation, we develop a criterion space search algorithm for solving any MIL-MMP. An extensive computational study on around 2000 instances illustrates that the proposed algorithm significantly outperforms existing methods/solvers.

2 - Generalized Mixed Integer Linear Maximum Multiplicative Programs: Multi-objective Optimization Approaches

Payman Ghasemi Saghand, University of South Florida, Tampa, FL, 33559, United States, payman@mail.usf.edu, Hadi Charkhgard

We study Integer Linear Generalized Maximum Multiplicative Programs (IL-GMMP). An IL-GMMP can be reformulated as a mixed integer Second-Order Cone Program and can be solved by commercial solvers such as IBM ILOG CPLEX, Gurorbi, and FICO Xpress. By showing that IL-GMMPs are special cases of optimization over the efficient set problems, we develop three exact solution approaches which only solve a number of single-objective integer linear programs to compute the optimal solution. We also draw an extensive comparison using the three commercial solvers. The results show that, by the right choice of the commercial solver, our proposed algorithms are significantly faster than other approaches.

3 - A Branch-and-Bound Algorithm for a Class of Mixed Integer Linear Minimum Multiplicative Programs: A Bi-Objective Optimization Approach

Vahid Mahmoodian, University of South Florida, Tampa, FL, 33620-5350, United States, Hadi Charkhgard, Yu Zhang

The branch-and-bound algorithm has been used to solve different types of mixed integer linear and even non-linear programming problems for decades. In this research, a new algorithm is introduced to solve the minimum bi-linear multiplicative programs as well as two branch-and-bound algorithms to solve mixed-integer minimum multiplicative programs. Moreover, an extensive computational study is done to show the effect of several proposed enhancements and capability of algorithms which shows that both algorithms perform well but one of them significantly outperforms SCIP so that it is up to 50.34 times faster only on the instances which are solved by both to optimality.

4 - Learning to Project in Multi-Objective Binary Linear Programming

Sierra Altamiranda Alvaro, University of South Florida, Tampa, FL, 33620-5350, United States, amsierra@mail.usf.edu, Hadi Charkhgard, Iman Dayarian, Ali Eshragh, Sorna Javadi

We study the possibility of improving the performance of multi-objective optimization algorithms using machine learning (ML). We focus on binary linear programs and employ the so-called KSA, a criterion space search algorithm. KSA computes all nondominated points of a problem by searching on a projected space. We present a ML approach to identify on which space the KSA should be projected. We also present a biobjective optimization based heuristic for selecting the best subset of features to avoid overfitting. Through an extensive computational study, we show performance improvement achieved by our ML method compared to a random selection of the projected space over several instances.

■ WA44

CC- Room 613

Computational Innovations in New Domains

Sponsored: Computing

Sponsored Session

Chair: Kiavash Kianfar, Texas A&M University, College Station, TX, 77843-3131, United States

Chair: Vishnu Vijayaraghavan, Texas A&M University

1 - Exact and Heuristic Methods for Solving the Bi Objective Maximal Covering Minimal Tour Problem

Sanaz Goldani, Analytics Software Tester, SAS/IDeaS, Cary, NC, 27606-5803, United States, sgoldan@ncsu.edu
Sanaz Goldani, Analytics Software Tester, North Carolina State University, Raleigh, NC, United States, sgoldan@ncsu.edu, Yahya Fathi

The Bi-objective maximal-Covering minimal-Tour Problem is a variation of the Covering Tour Problem in which our aim is to simultaneously minimize the travel distance and maximize the total demand covered. We tackle this problem using a branch-and-cut algorithm and a heuristic procedure in the context of the - constraint method. We present the results of our computational study on benchmark instances adapted from the literature.

2 - Matroid Based Decomposition Algorithms to Estimate the Reliability of Large Scale Structured Linear Sensor Networks

Vishnu Vijayaraghavan, Texas A&M University, College Station, TX, United States, vishnunitr@tamu.edu, Kiavash Kianfar, Yu Ding, Hamid R. Parsaei

Determining the reliability of a linear sensor system is a crucial problem in data analytics which directly impacts the design and operation of such systems. The runtime and the accuracy of Recursive Variance Reduction (RVR) methods to estimate reliability depend on the approach by which the minimal cut sets are obtained. We propose two matroid decomposition based RVR algorithms in which we utilize the structural properties inherent in clustered linear sensor systems to propose decomposition theorems based on matroid theory allowing for the disintegration of the problem into smaller subproblems over which the computations are performed.

3 - Optimum Search Schemes for Approximate String Matching Using Bidirectional FM-Index

Bahman Torkamandi, Texas A&M University, College Station, TX, United States, Kiavash Kianfar, Haochen Luo, Knut Reinert, Christoper Pockrandt

Approximate search in a text is a key problem in bioinformatics. Bidirectional indices and search schemes have opened possibilities to speed up the search by starting within the pattern and extending in both directions. However, finding optimal search schemes is a difficult combinatorial optimization problem. For the first time, we propose a mixed integer programming to find the exact optimal solution to this problem for the Hamming distance. Our experiments show that approximate matching of 101-bp DNA reads (with two errors) becomes 35 times faster than standard backtracking and the running time of in-index search using our optimal schemes is comparable to the state-of-the-art aligners.

4 - The Bi-criteria Set Covering Problem with Conflict Constraints

Saeed Saffari, Grubhub Holdings Inc., New York City, NY, 27695, United States, ssaffar@ncsu.edu, Yahya Fathi

We consider the well-known set covering problem with additional constraints that represent incompatibilities between certain pairs of columns (variables). We introduce this problem in a bi-criteria context in which we simultaneously maximize the number of covered rows (elements) and minimize the number of selected columns (nodes). We propose several classes of valid inequalities for the corresponding IP model, and demonstrate their effectiveness in the context of a branch and cut algorithm.

■ WA45

CC- Room 614

Methods for Large Scale, Nonlinear and Stochastic Optimization— IV

Sponsored: Optimization/Nonlinear Programming

Sponsored Session

Chair: Albert Solomon Berahas, Bethlehem, PA, 18018, United States

Chair: Alejandra Pena Ordieres, Northwestern University, Evanston, IL, 60208, United States

1 - Implicit Regularization and Solution Uniqueness in Over-parameterized Matrix Sensing

Anastasios Kyrillidis, Assistant Professor, Rice University, 3119 Duncan Hall, 6100 Main Street, Houston, TX, 77005, United States, anastasios@rice.edu

We consider whether algorithmic choices in over-parameterized linear matrix factorization introduce implicit regularization. The algorithm we study is factored gradient descent, where we model the low-rankness and PSD constraints through matrix factorization. Surprisingly, recent work argues that the level of rankness is not pivotal: even setting the factors as full square matrices is sufficient to find the low-rank solution, which suggests that operating over the factors leads to an implicit regularization. We show that under certain conditions, the PSD constraint by itself is sufficient to lead to a unique low-rank matrix recovery, without implicit or explicit low-rank regularization.

2 - Green Simulation Optimization Using Likelihood Ratio Estimators

Ben Feng, University of Waterloo, Waterloo, ON, N2J 4Y3, Canada, ben.feng@uwaterloo.ca, David J. Eckman

Green simulation reuses past simulation outputs to enhance the efficiency of current and future simulation experiments. One application of green simulation is in simulation optimization, wherein outputs from past iterations can be reused in subsequent iterations. We draw attention to challenges that arise when green simulation likelihood ratio estimators are naively employed in simulation optimization. In particular, we show that for searches that identify new designs based on past outputs, outputs in different iterations are conditionally dependent. We demonstrate how this conditional dependence and bias can adversely affect the behavior of gradient-based optimization algorithms.

3 - Derivative Approximation of Some Model-based Derivative Free Methods

Liyuan Cao, Doctoral Student, Lehigh University, Bethlehem, PA, 18015, United States, lic314@lehigh.edu, Albert Solomon Berahas, Katya Scheinberg

To optimize a black-box function, gradient-based methods can be used in conjunction with finite difference methods. Alternatively, optimization can be done with polynomial interpolation models that approximate the black-box function. A class of random gradient-free algorithms based on Gaussian smoothing of the objective function was analyzed by Yurii Nesterov in 2011. Similar random algorithms were implemented and discussed in the machine learning community in more recent years. We compare these methods on their accuracy of gradient approximation and the overall performance.

4 - Reduced-space Methods for LP Regularized Problems

Hao Wang, Shanghai Tech University, Shanghai, China

We propose a general algorithmic framework for solving the unconstrained lp regularized problems and estimate the lower bounds of the nonzero components. We show that the proposed algorithm detects the zero components during iteration using these lower bound estimation, so that fast local convergence can be achieved. Global and local convergence are analyzed. Numerical experiments demonstrates the efficiency of the proposed method.

■ WA46

CC- Room 615

Novel Traffic Signal Control Approaches

Sponsored: Transportation Science & Logistics/Intelligent Transportation Systems (ITS)

Sponsored Session

Chair: Ali Hajbabaie, Washington State University, Pullman, WA, 99164-2910, United States

1 - Time-Dependent Area Traffic Signal Control against Uncertainty

Suh-Wen Chiou, Professor, National Dong Hwa University, Hualien, Taiwan, chiou@mail.ndhu.edu.tw

A time-dependent traffic signal control model is presented for dynamic traffic assignment with users route choice. In the presence of uncertain travel demands, a time-dependent stochastic mathematical program with equilibrium constraints (SMPEC) is proposed. A bundle-like data-driven approach is proposed to effectively solve the SMPEC. Numerical experiments are conducted and comparison are empirically made with existing methods. It indicates that proposed model can achieve reliably better system performance in reducing traffic congestion over periods as compared to those did recent alternatives.

2 - Deep Learning Methods for Real Time Traffic Volume Prediction for Signalized Intersections

Xuegang Ban, Associate Professor, University of Washington, Seattle, WI, United States, banx@uw.edu, Wan Li

We propose a deep learning based method to predict real time short-term traffic volumes for signalized intersections. The predicted volumes can be used for optimizing real time traffic signal timing optimization

3 - Stochastic Gradient-based Optimal Signal Control with Energy Consumption Bounds

S.M. A. Bin Al Islam, North Carolina State University, Raleigh, NC, 37830, United States, H.M. Abdul Aziz, Ali Hajbabaie

This study develops a stochastic approximation-based traffic signal timing optimization model with bounds on network-level energy consumption. Due to the non-convex and non-linear structure of the energy consumption function, we utilize a stochastic approximation algorithm. We incorporate a simultaneous perturbation gradient estimation for solving the optimization problem. Our proposed gradient approximation technique guides the search directly towards the optimal solution. Empirical results show that it is possible to achieve optimized signal settings at a desired energy consumption bound for a network without compromising mobility performance.

4 - A Scaleable and Real-time Approach for Optimal Signal Control in a Multi-modal Semi-connected Vehicle Environment

S.M. A. Bin Al Islam, North Carolina State University, Raleigh, NC, 37830, United States, sislam5@ncsu.edu, Ali Hajbabaie

This research develops a multi-modal cell transmission model and integrates it into a mixed-integer linear program (MILP) to optimize the timing of signalized intersections. The proposed formulation explicitly accommodates multiple transportation modes and different connected vehicle market penetration rates. The proposed model formulation can correctly estimate traffic flow dynamics of transit vehicles. We have incorporated the proposed formulation in a distributed optimization algorithm. The results indicate significant improvement in network performance under various CV penetrations rates compared to existing transit signal priority approaches in a simulated environment.

■ WA47

CC- Room 616

Vehicle Routing III

Contributed Session

Chair: Yajing Chen, Shanghai Jiao Tong University, Xuhui District, Shanghai, 200030, China

1 - Statistical Models in Vehicle Routing

Debdatta Sinha Roy, Robert H. Smith School of Business, University of Maryland, College Park, MD, United States, debsroy@rhsmith.umd.edu, Bruce L. Golden, Edward Andrew Wasil, Xingyin Wang, Adriano Masone

Delivery and service companies send out vehicles to deliver customer products and provide services. For the capacitated vehicle routing problem, we show that reducing route variability while generating the routes is an important consideration to minimize the total operating and delivery costs for a company when met with random traffic. Routing companies participating in competitive bidding might need to respond to a large number of requests regarding route costs in a very short amount of time. For the close enough traveling salesman problem with customer locations distributed randomly and all customers having the same radius, we estimate the route length using information about the instances.

2 - An Exact Algorithm for Electricity AGV Routing with Pickup and Delivery Time Windows

Wei Zhang, National University of Singapore, Singapore, Singapore, Chenhao Zhou

In the operations of modern ports, the electricity AGVs are broadly used for container transferring, as it can work more efficiently and save manpower. Besides the common constraints in the traditional vehicle routing problems, there is an additional limit for the electricity AGV on its travel distance before recharging. To reduce the charging time, the battery swap scheme is becoming a more attractive solution. Bearing this in mind, along with the pickup and delivery time windows, it is even more complicated than the general vehicle routing problem. To solve this problem, we utilize the Lagrangian relaxation method and a dynamic programming.

3 - Vehicle and Pedestrian Routing Problem with Parking Space in the Last Mile Logistics

Gitae Kim, Hanbat National University, Daejeon, Korea, Republic of, gitaekimemail@gmail.com

The difficulty of the problem is compounded when we think of it in an urban area. Over the years, the importance of the final leg of delivery to customers has increased through the realization that Vehicle Routing Problem constitutes a large part of logistics operations in terms of cost, time, and service level. Due to the complicated buildings and limitation of parking space, it is hard to estimate the travel time with only road network. Thus, this paper combines VRP with pedestrian routing problem in the last mile delivery. We consider the parking space when the vehicle arrives at each customer site. We propose a multi objective model for the problem and provide the numerical results to present the models.

4 - Data-driven VRP with Time Dependent Cost Function

Sami S. Ozarik, Eindhoven University of Technology, Eindhoven, Netherlands, s.s.ozarik@tue.nl, Lucas Petrus Veelenturf, Tom Van Woensel, Gilbert Laporte

The recent increase in online orders leads to logistical challenges such as low hit rates (number of successful deliveries) and unattended deliveries. In this paper, we consider exact and heuristic approaches in order to solve last mile delivery problems in which customers' attendance probability data is considered for each of the time buckets in the planning horizon. We aim to improve the hit rate by considering routing and scheduling decisions. We develop an efficient heuristic approach by iteratively solving routing and scheduling problems. Numerical results will be presented.

5 - Minmax Vehicle Routing Problem in a Megacity – Comparison Two Heuristics

Jihyun Jo, Pennsylvania State University, University Park, PA, United States, JZJ5077@psu.edu, Soundar Kumara

We consider the min-max vehicle routing problem for a large franchise system in a megacity. There are several characteristics of a megacity delivery network such as high node density, huge gaps between delivery locations and distribution centers and etc. To solve this routing problem, we proposed the "Route first - Partition second" method with genetic algorithm in the earlier study. In this study, we compare this method and another method which is a reverse way (Partition first - Route second). Due to the distinctive features of the megacity delivery network, we find out that our earlier method is better than the second method in both solution wise and CPU time wise.

6 - Two-sided Matching Model Between Surgeons and Patients in Elective Surgery Considering No Show and New Patient Arrival

Yajing Chen, Shanghai Jiao Tong University, Shanghai, China

With the reform of the medical system, people are getting more and more demanding on the quality of medical services. How to ensure that patients receive satisfactory service is a problem of great concern to hospitals.In real life, there is a situation of patients' no show which will lead to a waste of medical resources.How to improve the utilization rate of resources is also a matter of great concern to hospitals.In this paper, we give a two-sided matching model for surgeons and patients in elective surgery considering patients' no show and new patients' arrival.

■ WA48

CC- Room 617

Joint session TSL/OPT.under Uncertainty: ADP/Reinforcement Learning in Vehicle Routing II

Sponsored: Transportation Science & Logistics/Freight Transportation & Logistics

Sponsored Session

Chair: Jorge Mendoza

1 - A Dynamic Pickup and Delivery Problem with Transfers

Albert H. Schrotenboer, University of Groningen, Vlasstraat 19, Groningen, 7912KS, Netherlands, a.h.schrotenboer@rug.nl, Paul Buijs, Onur A. Kilic, Marlin Wolf Ulmer, Michiel uit het Broek

We study a dynamic pickup and delivery problem with transfers inspired on the daily operations of a bike courier company in Groningen, The Netherlands. Multiple couriers are managed dynamically to satisfy pickup and delivery requests. In addition, small city distribution centers are utilized to allow for the transfer of parcels between couriers. We present and compare different Approximate Dynamic Programming (ADP) approaches for modeling and solving the problem of managing this fleet of couriers most efficiently. In the context of ADP, we present different approaches for assigning requests to bike couriers and study how to ensure that parcels are transferred between couriers efficiently.

2 - Dynamic Repositioning in Free-floating Bike Sharing Systems Using Approximate Dynamic Programming

Xue Luo, Tsinghua University, Beijing, China, luoxue16@mails.tsinghua.edu.cn, Li Li, Lei Zhao

In bike sharing systems, bike flows are dictated by customers' travel patterns. As a result, the imbalance of customer flows leads to the shortage of bike supplies in some area and overage in some others. Repositioning must be performed to restore balance to the system, dynamically or statically. We present a stochastic dynamic program for dynamic repositioning, with explicit consideration of the characteristics of free-floating systems. We examine the effectiveness and efficiency of several approximate dynamic programming (ADP) algorithms. Highlighting the time-variance of stochastic demand and supply, we conduct extensive numerical experiments and gain useful managerial insights.

3 - Deep Q-learning for Same-day Delivery with a Heterogeneous Fleet of Vehicles and Drones

Xinwei Chen, University of Iowa, Iowa City, IA, 52242, United States, Marlin Wolf Ulmer, Barrett Thomas

As e-commerce continues to expand, retailers offer faster deliveries to stay competitive. Same-day and instant delivery are expected to reach a combined share of 15% of the market by 2020. To overcome the cost challenges in same-day delivery, companies have begun to use drones. We introduce a deep Q-learning (DQL) approach to study same-day delivery with a heterogeneous fleet of vehicles and drones. The DQL policy significantly outperforms benchmark policies. We will explore how feature selection impacts the learning, discuss the value of rejecting feasible requests, and illustrate the DQL policy with visualizations.

4 - Solving the Stochastic Vehicle Routing Problem with Reinforcement Learning

Tao Li, Lehigh University, Bethlehem, PA, United States, tal214@lehigh.edu, Larry Snyder, Martin Takac

We propose a reinforcement learning (RL) algorithm to solve the stochastic vehicle routing problem (SVRP), in which the demands and distances are related to features such as temperature and humidity. We compare the results with approximate and exact solutions coming from stochastic programming approaches. In SVRP, the optimal solution is highly dependent on the problem instance. Therefore, instead of predicting the demands and distances based on the features for each instance, we propose a structure to learn the input information, and the relationship between the inputs and the features. Then we use a pointer network, trained with an actor-critic algorithm, to make decisions in the RL framework.

5 - Atari-ing the Vehicle Routing Problem with Stochastic Requests

Jorge E. Mendoza, Visiting Professor, HEC Montréal, Montreal, QC, Canada, jorge.mendoza@hec.ca, Clément Grodecoeur, Nicholas D. Kullman, Martin Cousineau, Justin Goodson

Deep reinforcement learning (RL) has seen much recent success in solving tasks that involve sequential decision making under uncertainty. One of the most celebrated applications is gaming. Deep RL has been used to develop a single agent capable of outperforming humans on a majority of classic Atari 2600 games — considered a milestone in the progression towards more general artificial intelligence. In this work, we attempt to represent a classical logistics problem, namely the Vehicle Routing Problem with Stochastic Requests, as such a video game and employ deep RL tactics to solve it. We compare this approach to classical solution methods from approximate dynamic programming.

■ WA49

CC- Room 618

Inventory Management I

Contributed Session

Chair: Sangjo Kim, Shanghai University of Finance and Economics

1 - An Efficient Decomposition Method for the General-product Structure Assemble-to-order System

Mohsen Elhafsi, University of California-Riverside, Riverside, CA, United States, melhafsi@ucr.edu, Jinaxin Fang, Essia Hamouda

We consider a general-product structure ATO problem which we model as an infinite horizon discounted MDP. Obtaining the optimal control policy of such a system is computationally intractable. As such, we develop a heuristic policy (DHP) based on a decomposition of the ATO system into a series of two-component, multi-demand-class M-product structure ATO subsystems. Exploiting the structure of the optimal policy of such subsystems, we show that the DHP possesses many properties similar to those encountered in special-product structure ATO systems. Extensive numerical experiments show that the DHP is very efficient and compares favorably to other proposed heuristics in the literature.

2 - Risk Averse Inventory Management under Autocorrelated Log-log Demand Series

Ting Wang, University of Science and Technology of China, Hefei, China, sa172040@mail.ustc.edu.cn, Yugang Yu, Ye Shi

Motivated by the practice of a food manufacturer, we conduct predictive analysis on its data and find that the demand process of FMCG (Fast Moving Consumer Goods) can be well characterized by an autocorrelated log-log demand series. Under the new demand structure, we study a risk averse inventory management problem and examine the properties of the optimal order policy with respect to the degree of risk aversion, where the optimal order quantity does not necessarily increases as the degree of risk aversion increases. In addition, we also investigate the bullwhip effect under the autocorrelated log-log demand series and find that the risk aversion behavior may affect bullwhip effect.

3 - Clustering Retail Stores for Inventory Transshipment

Emily Barbee, University of Alabama, Tuscaloosa, AL, United States, ecbarbee@crimson.ua.edu, Burcu B. Keskin

We investigate a transshipment problem with a large network of retail stores. Specifically, we design clustering approaches for the efficient and effective transshipment of goods inside large networks. Using a large grocery retailing data set with multiple products across two large and closely located metropolitan areas, we derive product level and retailer level insights and investigate the validity of several common assumptions present in the literature.

4 - Optimal Consignment Stocking Policy under Uncertainty

Md Shahriar J. Hossain, Northwestern State University, Natchitoches, LA, 71457-5947, United States, msjhossain1@gmail.com, Bhaba R. Sarker

Consignment stocking is an effective approach to bring a product next to the door of a consumer. This supply chain system often encounters both demand and lead-time uncertainty, as well as space and shelf life constraints. In this paper, a joint total cost model is developed and solved to determine the optimum order quantity and reorder point for a single-vendor, single-retailer consignment stocking system. The solution procedure varies depending on the distribution of demand and lead time. For uniformly distributed demand and lead time a gradient method is applied with an iterative search procedure. In case of normal distribution, an exhaustive search procedure is followed within certain domains.

5 - The Optimal Policy for Periodic Stocking and Bundling

Sangjo Kim, Shanghai University of Finance and Economics, Shanghai, China, sangjo@sufe.edu.cn, Youyi Feng, Jianjun Xu

We investigate the optimal policy for joint inventory replenishment and bundling decisions, where a seller periodically replenishes individual products as well as bundles them to another selling item. The seller backlogs unmet demands and carries over unsold items aiming to minimize the total discounted cost over a finite horizon. We reveal that there exists an economic relationship such that each pair of the bundle and an individual product should be regarded as substitutes while each couple of individual ones as complements. We characterize the optimal policy and propose efficient algorithms to compute the policy as well as provide a myopic policy that may be optimal under certain regularities.

■ WA50

CC- Room 619

Transportation, Maritime

Contributed Session

Chair: Hassan Sarhadi, Acadia University, St. John's, NL, A1B 3S7, Canada

1 - Yard Crane Scheduling in a New Automated Container Terminal Design

Xin Jia Jiang, Nanjing University of Aeronautics and Astronautics (NUAA), Nanjing, China

To reduce the time wasted in the yard crane (YC) gantry moves, a new design has been proposed to install a rail-mounted ground trolley (GT) along each block for container delivery. The GT based Automated Container Terminal (GT-ACT) is proven to be very effective in operation, but the interaction between YC and GT increases the planning difficulty of container handling. At the operational level, the container handling efficiency highly depends on the YC scheduling decisions. An interesting YC scheduling problem with GT collaboration is formally discussed in this study. The VRP related modeling and solution approaches will be shared.

2 - Container Handling and Layout Optimization in Empty Container Depots

Erhan Karakaya, PhD Student, Auburn University, Auburn, AL, United States, erhan@auburn.edu, Julio Jiménez, Jimena Pascual, Alice E. Smith

We propose an analytical method and develop a simulation model to improve handling operations for empty container depots. We consider the design of the block layout of the depot to minimize the expected handling of containers due to retrievals and arrivals. Alternative policies regarding retrieval are assessed. Empty container depots are ubiquitous in the global supply chain but differ in significant ways from the more often studied maritime ports. This is one of the very few studies to specifically address empty container depots.

3 - Simulation Optimization Iteration Approach on Traffic Integrated Yard Allocation Problem in Transshipment Terminals

Qitong Zhao, National University of Singapore, Singapore,zhaoqitong@u.nus.edu, Loo Hay Lee, Ek Peng Chew

To improve the efficiency of the container terminals, we propose a simulation optimization iteration approach to integrate the yard allocation problem (YAP) with traffic system. YAP is formulated as a mixed integer programming model with the objective to reduce the total job travel time. A discrete event simulation model is developed to simulate traffic and the terminal operation. The approach solves two models iteratively to improve the allocation decisions. Experiment results show that this approach can generate yard allocation decisions to reduce the overall traffic time comparing with traditional intuitive rules.

4 - A Distributionally Robust Optimization Approach for Marine Search and Rescue Operations

Hassan Sarhadi, Assistant Professor, F.C. Manning School of Business, Acadia University, Wolfville, NS, Canada, hassan.sarhadi@acadiau.ca

Search and Rescue (SAR) operation is a critical component of marine activities as it reduces the loss of life, injury, and property damage following marine incidents, thereby mitigating the risks involved with marine activities. This research intends to formulate the problem of allocating SAR vessels to response stations by taking into account the uncertain nature of incidents. To this end, a distributionally robust optimization approach is proposed to model the underlying uncertainty of this problem.

■ WA51

CC- Room 620

Joint Session AAS/TSL Air: Deep Learning Technologies in ATM/UTM

Sponsored: Aviation Applications

Sponsored Session

Chair: Yulin Liu, University of California-Berkeley, University of California-Berkeley, Berkeley, CA, 94709, United States

1 - Autonomous Air Traffic Controller: A Deep Multi-Agent Reinforcement Learning Approach

Marc Brittain, Iowa State University, Ankeny, IA, 50021, United States, mwb@iastate.edu, Peng Wei

Ensuring high-density air transportation systems of the future are both safe and efficient is a top priority. With the growing air traffic complexity in traditional and low altitude airspace, an autonomous air traffic control system is needed to ensure safe-separation requirements. We propose a deep multi-agent reinforcement learning framework that is able to identify and resolve conflicts between aircraft in a high-density, stochastic, and dynamic en-route sector with multiple intersections. We show that our framework is both scalable and efficient for large number of incoming aircraft to achieve extremely high traffic throughput.

2 - Generative Adversarial Networks for Synthetic Generation of Tactical Reroutes

James Calvin Jones, MIT Lincoln Laboratory, Lexington, MA, 02140, United States, Changming Xu, Yan Glina

We propose the use of Generative Adversarial Networks (GANs) in the Air Traffic Management context for the generation of synthetic reroutes around convective weather areas. This talk explores the characteristics of tactical reroutes generated by the GAN framework for trajectories in the Northeast United States.

3 - Towards the Next Generation Airline Revenue Management: A Deep Reinforcement Learning Approach to Seat Inventory Control and Overbooking

Syed A.M. Shihab, Iowa State University, Ames, IA, United States, shihab@iastate.edu, Caleb Logemann, Deepak-George Thomas, Peng Wei

In this paper, the seat inventory control and overbooking problem of airline revenue management has been tackled by first casting it as a Markov Decision Process and then using Deep Reinforcement Learning with the goal of maximizing the revenue for each flight departure to find the optimal policy. To generate data and train the agent, a basic air-travel market simulator was developed. The performance of the agent in different simulated market scenarios was compared against theoretically optimal solutions and was found to be nearly close to the expected optimal revenue.

4 - Autonomous UAS Traffic Management System for Multi-aircraft Coordination

Xuxi Yang, Iowa State University, Iowa State University, Ames, IA, 50011, United States, xuxiyang@iastate.edu, Yulin Liu, Peng Wei

Flying with electrical vertical takeoff and landing (eVTOL) aircraft will bring fundamental changes to city infrastructures and daily commutes. To enable safe and efficient autonomous on-demand free flight operations for the eVTOL aircraft, a centralized computational guidance algorithm is proposed and analyzed for multi cooperative aircraft. By generating real-time actions for all the aircraft to follow, the algorithm can guide all the aircraft to their respective destinations while avoiding conflicts between them. For illustration, a free flight airspace simulator is created to test the performance of this algorithm.

■ WA52

CC- Skagit 1

Dynamic Pricing in Network Settings

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Yash Kanoria, Columbia Business School, New York, NY, 10027, United States

Chair: Pengyu Qian, Columbia University-Graduate School of Business, Columbia University-Graduate School of Business, New York, NY, 10027, United States

1 - Near Optimal Control of a Ride-hailing Platform via Mirror Backpressure

Pengyu Qian, Columbia University-Graduate School of Business, Columbia Business School, c/o PhD Office, New York, NY, 10027, United States, PQian20@gsb.columbia.edu, Yash Kanoria

Ride-hailing platforms need to match supply and demand so as to maximize payoff under the geographical flow constraints. We consider two platform control settings: joint entry-assignment (JEA) and joint pricing-assignment (JPA). We introduce a novel family of Mirror Backpressure (MBP) policies which are simple, practical, and do not require knowledge of the demand arrival rates. MBP generalizes Backpressure policy such that it executes mirror descent. MBP loses at most $O(K/T + 1/K)$ fraction of the achievable payoff in JEA and $O(\sqrt{(K/T + 1/K)})$ fraction in JPA, where K is the number of vehicles and T is the horizon. Simulation results in a realistic environment support our theoretical findings.

2 - Network Revenue Management with Online Inverse Batch Gradient Descent Method

Cong Shi, University of Michigan, 2257 Woodhaven Ct, Ann Arbor, MI, 48105, United States, Yiwei Chen

We consider a general class of price-based network revenue management problems that a firm aims to maximize revenue from multiple products produced with multiple types of resources endowed with limited inventory over a finite selling season. A salient feature of our problem is that the firm does not know the underlying demand function that maps prices to demand rate, which must be learned from sales data. We propose a novel nonparametric learning algorithm termed online inverse batch gradient descent (IGD) algorithm. For large scale systems, we establish a dimension-independent regret bound. This result is independent of the number of products and resources and works well for a continuum price set.

3 - Finite-time Analysis of Distributed TD(0) with Linear Function Approximation

Thinh Doan, Georgia Institute of Technology, Atlanta, GA, United States, thinhdoan@gatech.edu

We study the policy evaluation problem in multi-agent reinforcement learning, where a group of agents works cooperatively to evaluate the value function for the global discounted accumulative reward. For solving this problem, we consider a distributed variant of the popular TD methods. Our main contribution is providing a finite-time analysis for the convergence of this method. Our results mirror what we would expect from using distributed stochastic gradient descent for solving convex optimization problems.

4 - Menu Design of a Bipartite Matching Queueing System with Strategic Users

Lisa Hillas, University of Chicago, Chicago, IL, United States, Rene A. Caldentey, Varun Gupta, Christopher Ryan

In this talk, we explore the optimal design of matching topologies for a multi-class multi-server queueing system under a FCFS-ALIS service discipline. We investigate the performance of the system from the perspective of a central planner who must design a menu of service classes, which are defined by the subset of servers that can serve each class. Customers are heterogeneous on their preferences over servers and self-select the service class to join.

■ WA53

CC- Skagit 2

Managing On-demand Platforms

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Murray Lei

1 - Dynamic Pricing and Matching in Ride-hailing Platforms

Chiwei Yan, Uber Technologies, San Francisco, CA, United States, Nikita Korolko, Dawn Woodard, Helin Zhu

Advanced matching and dynamic pricing algorithms are the two key levers in ride-hailing platforms. We give a brief overview of state-of-the-art matching and pricing algorithms run by these platforms. We then demonstrate via a stylized model, calibrated with Uber data, that the synergy of these two levers can bring significantly more benefits. To be specific, we study a novel matching mechanism called dynamic waiting. We show that pricing and waiting could be jointly optimized in reducing rider and driving waiting times, lowering price volatility, and increasing trip volume and welfare.

2 - Charging Electric Vehicle Sharing Fleet

Long He, National University of Singapore, Singapore, Singapore, longhe@nus.edu.sg, Guangrui Ma, Wei Qi, Xin Wang

We develop models to jointly optimize the sites and sizes of charging stations, along with the coupled fleet charging and repositioning operations. Our nonlinear optimization model closely tracks EV energy levels and explicitly depicts stochastic charging operations. We conduct a case study with data sets of Car2Go's operations.

3 - Dynamic Labor Rebalancing for a On-demand Delivery Model

Murray Lei, Queen's University, 465 Goodes Hall, 143 Union Street W, Kingston, ON, K7L 3N6, Canada, yl64@queensu.ca, Stefanus Jasin, Jingyi Wang

We study a problem of incentivizing a proper number of workers to match with demand in the context of on-demand delivery. Demand for delivery during a specific time slot arrives sequentially over time. The firm sends multiple rounds of incentives to a finite pool of potential workers. At the beginning of each round, the firm decides how many incentives to send to which group of potential workers. Workers may respond positively or negatively, or simply don't respond. The objective is to minimize the regret, defined as the gap between the final number of workers and demand. We propose an algorithm that easily computes the number of incentives to send, and show that it achieves near-optimal regret.

4 - A Pricing Framework for the Multi-modal Mobility Marketplace

Chamsi Hssaine, Cornell University, Ithaca, NY, Siddhartha Banerjee, Ragavendran Gopalakrishnan

We study the problem of designing an efficient mobility marketplace: a centralized platform where private on-demand mobility providers and public transit can jointly offer hybrid multi-modal trips to commuters. Pricing such trips to maximize social welfare, while ensuring that both commuters and mobility providers enjoy weak Pareto improvement (compared to the status quo), is a hard problem. Our general approach is based on formulating a "shaded" welfare maximization program and yields a pricing policy with a constant-factor approximation guarantee, under an intuitive structural condition based on a notion of the "efficiency gains" from introducing multi-modal trips.

■ WA54

CC- Skagit 3

Operations, Revenue, and Learning Theory

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Rad Niazadeh, Stanford University, Stanford University, Stanford, CA, 94305, United States

1 - Selling to a No-regret Buyer

Seth Matthew Weinberg, Princeton, Princeton, NJ, 08540, United States, Mark Braverman, Jieming Mao, Jon Schneider

We consider the problem of a single seller repeatedly selling a single item to a single buyer (specifically, the buyer has a value drawn fresh from known distribution D in every round). Prior work assumes that the buyer is fully rational and will perfectly reason about how their bids today affect the seller's decisions tomorrow. In this work we initiate a different direction: the buyer simply runs a no-regret learning algorithm over possible bids. We provide a fairly complete characterization of optimal auctions for the seller in this domain.

2 - Efficient Learning in Online Auctions

Nika Haghtalab, Cornell University, Ithaca, NY, United States

We consider the design of computationally efficient online learning algorithms and their applications to auction design. We present an algorithm called Generalized Follow-the-Perturbed-Leader and provide conditions under which it is oracle-efficient while achieving vanishing regret. Our auction-design framework considers an auctioneer learning an optimal auction for a sequence of adversarially selected valuations with the goal of achieving revenue that is almost as good as the optimal auction in hindsight. We give oracle-efficient learning results fora number of commonly used auctions in practice.

3 - Semi-parametric Efficient Policy Learning with Continuous Actions

Vasilis Syrgkanis, Microsoft Research, Cambridge, MA, 02139, United States, vasy@microsoft.com

We consider off-policy evaluation and optimization with continuous action spaces. We focus on observational data where the data collection policy is unknown. We take a semi-parametric approach where the value function takes a known parametric form in the treatment, but we are agnostic on how it depends on the observed contexts. We propose a orthogonal/doubly robust off-policy estimate for this setting and show that off-policy optimization based on this estimate is robust to estimation errors of the policy function or the regression model. We provide an experimental evaluation of our method in a synthetic data example motivated by personalized pricing and resource allocation.

4 - Regret Analysis of Bayesian Multi-armed Bandit with Many Arms

Khashayar Khosravi, Stanford University, Stanford, CA, 94305, United States, khosravi@stanford.edu, Mohsen Bayati, Nima Hamidi, Ramesh Johari

We consider the Bayesian multi-armed problem in the presence of many arms and provide lower bounds on the regret of all policies. We also design and analyze algorithms that can achieve these regret bounds. Through simulations, we confirm our theoretical results and demonstrate that the proposed methods work well in practice.

■ WA55

CC- Skagit 4

RM from a Customer Lifetime Value Perspective

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Dragos Florin Ciocan, INSEAD, Fontainebleau, France

1 - Are Markets with Loss-averse Consumers More Sensitive to Losses?

Zhenyu Hu, National University of Singapore, 15 Kent Ridge Drive, Mochtar Riady Building, BIZ1 8-69, Singapore, 119245, Singapore, Javad Nasiry

Behavioral pricing and revenue management aim to incorporate realistic consumer behavior into firms' pricing and inventory models. The key input to these models is market demand, which is often assumed to inherit the characteristics of consumer behavior—as when, for example, one assumes that a market consisting of loss-averse consumers is more responsive to losses than to gains. The empirical evidences on loss-sensitive demand, however, are frustratingly mixed. We offer one explanation on why gain-sensitive demand and loss-averse consumers can coexist by accounting for the heterogeneity in consumer valuation and examine its implication on the firm's optimal pricing policies.

2 - RM with Repeated Interactions

Dragos F. Ciocan, INSEAD TOM Department, Fontainebleau, France, Andre Du Pin Calmon, Gonzalo Romero

Motivated by online advertising, we model and analyze a revenue management problem where a platform interacts with a set of customers over a number of periods. Unlike traditional NRM, we consider customers who dynamically change state between periods. Customer state depends on the quality of their past service and determines the amount of budget that they allocate to the platform. These dynamics create a tradeoff between the platform myopically maximizing short-term revenues, versus maximizing the long-term goodwill of its customers. We identify reasonable conditions under which myopic policies that ignore the budget dynamics are either optimal or near-optimal.

3 - Value of Promotions with Delayed Incentives: An Empirical Investigation of Gift Card Promotions

Ozalp Ozer, The University of Texas at Dallas, Richardson, TX, 75080-3021, United States, Bharadwaj Kadiyala, A. Serdar Simsek

Gift card promotions provide customers an incentive to spend more than an expenditure threshold on regularly priced (as opposed to discounted) products, by rewarding customers with a gift card. This type of promotion is gaining significant popularity among luxury fashion, department store, and consumer electronic industries. Using a proprietary data set from a large department store, we investigate how customers respond to these promotions as well as its effectiveness as a promotional vehicle for retailers. We find significant and positive effects on both purchase likelihood of customers and total sales of the retailer.

4 - Efficient Strategic-level Repositioning in Vehicle-sharing Networks

Gonzalo Romero, Rotman, University of Toronto, Toronto, ON, M4K 3H6, Canada, gonzalo.romero@rotman.utoronto.ca, Mahsa Hosseini, Joseph Milner

We study the dynamic problem of repositioning vehicles using steady-state behavior for a network with centralized control and uncertain, unbalanced demand. We provide interpretable strategic level reposition policies via absorbing Markov chain concepts. Specifically, we use the structure of the underlying transition matrix to estimate the relocation gradient as a function of the current number of vehicles in each location These gradients then provide a state-dependent heuristic for the dynamic vehicle repositioning problem.

■ WA56

CC- Skagit 5

Marketing III

Contributed Session

Chair: Ankita Sahai, IIM Indore, FPM Residence, Indore, 453556, India

1 - A Study on Saddle in New Product Diffusion Processes

Masahiro Ishii, Professor, Sophia University, Chiyoda-ku, Tokyo, Japan, Hideyuki Takenouchi, Yoko Sugitani, Ichiro Takahashi

After Bass (1969) applied a diffusion model to describe innovation adoption curves of eleven durable goods, a large number of papers has addressed the related issues. One of the main streams of literature has been emerged in modelling the spread of innovations throughout their entire life cycle. Then, we develop an extended Bass model to reflect complexities, especially saddles, in market penetration curves of new products. In the model, social factors such as social character, social networks, and network externalities etc. are employed as explanatory variables.

2 - Enhancing Return Flexibility Through the Cooperation Between Competitive Retailers

Yi Chen, Xi'an Jiaotong University, Xi'an, China, chenyic@stu.xjtu.edu.cn, Qin Su

Given the importance of return flexibility to consumer shopping experience, our study focuses on the cooperation between competitive retailers with the aim of higher return flexibility. We build an analytical model to explore whether and when two competing brick-and-mortar retailers should accept returns from their online competitor. When store traffic is valuable, we investigate how the cooperation with online retailer in handling returns changes brick-and-mortar retailers' pricing strategies and equilibrium outcomes.

3 - The Impact of Tourist's Level of Mindfulness on Tourism Satisfaction and Experience

Ankita Sahai, Indian Institute of Management Indore, Indore, India, f17ankitas@iimidr.ac.in, Rajendra V. Nargundkar

This study aims to explore the impact of level of mindfulness of a tourist on his/her level of satisfaction and experience with the tourism destination. In the literature, mindfulness has been linked with wellness, but linkages between mindfulness, tourist satisfaction and tourism experience remain unexplored. In the context of tourism in India, we investigate whether mindful tourists gain higher sense of satisfaction and better experiences with tourism. The results of the study may help in determining whether there exists the potential for creating a niche for mindful tourists within a destination. The destination may be branded as a mindful tourism destination.

■ WA57

CC- Yakima 1

Optimizing Public Policy

Sponsored: Public Sector OR

Sponsored Session

Chair: Nick Arnosti

1 - Designing Fair, Efficient, and Interpretable Policies for Prioritizing Homeless Youth for Housing Resources

Phebe Vayanos, University of Southern California, University Park Campus, USC, Viterbi School of Engineering, Los Angeles, CA, 90089, United States, phebe.vayanos@usc.edu, M.J. Azizi, Bryan Wilder, Eric Rice, Milind Tambe

We consider the problem of designing fair, efficient, and interpretable policies for prioritizing heterogeneous homeless youth on a waiting list for scarce housing resources of different types. We propose a data-driven mixed-integer optimization framework for designing point-based policies that use features of the housing resources and the youth to maximize the probability that the youth will have a safe and stable exit from the housing program. We evaluate our framework using real-world data from the United States homeless youth housing system.

2 - Analyzing the Effects of Judge Rotation and Judge Shopping on Criminal Sentencing

Lawrence M. Wein, Stanford University, Graduate School of Business, 655 Knight Way, Stanford, CA, 94305-5015, United States, lwein@stanford.edu, Can Wang

Motivated by data from South Carolina, which rotated judges throughout the state on a weekly basis, we analyze a model in which defendants wait for a lenient judge before plea bargaining. We look at the impact of four factors on the mean and variance of criminal sentences: the amount of judge rotation, the amount of allowable judge shopping, the transparency of the judges' schedules, and the capacity utilization of the judicial system.

3 - Redistricting Liver Allocation: A Simulation-optimization Approach

Theodore Papalexopoulos, MIT, Cambridge, MA, United States, tpapalex@mit.edu, Dimitris Bertsimas, Nikolaos Trichakis, Yuchen Wang, Ryutaro Hirose, Parsia Vagefi

We develop a simulation-based optimization algorithm for districting in deceased-donor liver allocation. The algorithm partitions the United States' 58 donor service areas to minimize a weighted sum of annual mortality and organ transport distance in simulation. Graph-based machine learning models capture the simulator's output and allow for an efficient local search procedure to select desirable districts. Our results are part of broader work analyzing efficiency and fairness tradeoffs in liver transplantation policy design.

4 - Jumping the Line, Charitably: Analysis and Remedy of Donor-priority Rule

Ronghuo Zheng, University of Texas at Austin, Austin, TX, 78723, United States, ronghuo.zheng@mccombs.utexas.edu, Tinglong Dai, Katia P. Sycara

We develop a parsimonious model of organ donation to analyze the welfare consequences of introducing the donor-priority rule. Assuming heterogeneity in the cost of donating only, we find introducing donor-priority rule improves social welfare. By incorporating heterogeneity in the likelihood of requiring an organ transplant and in organ quality, we show that introducing donor-priority rule can lower social welfare due to unbalanced incentives across different types of individuals. We then consider a freeze-period remedy and show this additional friction helps rebalance the incentive structure, and in conjunction with the donor-priority rule, can guarantee an increase in social welfare.

■ WA58

CC- Yakima 2

Humanitarian and Disaster Operations Management

Sponsored: Public Sector OR

Sponsored Session

Chair: Arian Aflaki

1 - Donations for the Refugee Crisis: Cash Versus In-kind Assistance

Telesilla O. Kotsi, Kelley School of Business, Indiana University, Bloomington, IN, 47401, United States, tkotsi@indiana.edu, Owen Wu, Alfonso J. Pedraza-Martinez

Motivated by our fieldwork during the humanitarian responses to the 2017 refugee crisis in north-western Greece, we analyze trade-offs between cash and in-kind assistance that a humanitarian organization offers to refugees. Our goal is to help humanitarian organizations and governments improve the mix of assistance to maximize the overall benefits to refugees, local business, and residents. Cash assistance allows refugees' spending flexibility and supports local economy, but is complicated by the presence of market power of the local retailer. We examine the impact of market structures, specifically the government's involvement, on the assistance decision of humanitarian organizations.

2 - Evaluating Strategies for Intraorganizational Information Management in Humanitarian Response

Erica L. Gralla, George Washington University, Washington, DC, 20052, United States, egralla@gwu.edu

Information management is critical in humanitarian response, but there is little guidance for humanitarian organizations on how to set up internal information management processes. We use an agent-based model to evaluate several strategies for intra-organizational information management. The results show that holding regular information-sharing meetings significantly reduces the time to acquire adequate information, but does not reduce information overload; however, deploying an information management specialist reduces both time required and information overload. We conclude with recommendations for humanitarian organizations setting up information management processes.

3 - Joining a Humanitarian Coalition: An Empirical Investigation

Maria Besiou, Kuehne Logistics University, Hamburg, 50100, Germany, Mahyar Eftekhar

This study examines the impact of supply availability, scale and magnitude of demand, and environmental conditions on humanitarian organizations' field coordination pattern. This empirical study is based on a unique data set of interactions among humanitarian organizations in 45 countries, during emergency relief operations, from 2006 to 2018.

4 - Evaluating Strategies for Intraorganizational Information Management in Humanitarian Response

Lauren Bateman

Information management is critical in humanitarian response, but there is little guidance for humanitarian organizations on how to set up internal information management processes. We use an agent-based model to evaluate several strategies for intra-organizational information management. The results show that holding regular information-sharing meetings significantly reduces the time to acquire adequate information, but does not reduce information overload; however, deploying an information management specialist reduces both time required and information overload. We conclude with recommendations for humanitarian organizations setting up information management processes.

5 - Reliable Transportation Procurement in Humanitarian Sector: A Data-driven Approach

Feyza G. Sahinyazan, Simon Fraser University, Vancouver, BC, Canada, feyza_sahinyazan@sfu.ca, Mare-Eve Rancourt, Vedat Verter

Aid organizations choose their service providers through reverse auctions to decrease their logistics costs. Most aid organizations award their contracts to the lowest bidders, which often yield aggressive bidding and eventually low quality of service. This problem is known as abnormally low bids (ALB) in public procurement. scrutinizing service levels. Current literature on ALBs is rather limited. In this study, we develop a data-driven contract awarding framework that estimates "reasonable" rates based on lane and contract specifications and eliminates ALBs. Our results demonstrate that service levels can be improved significantly with the suggested framework.

■ WA58a

CC- Chelan 1

8:00-8:45 IBM
8:45-9:30 DecisionBrain

Vendor Tutorial

1 - A Closer Look: Launching your Optimization Application in Minutes

Filippo Focacci, Decision Brain, 18 rue Yves Toudic, Paris, 75010, France, Michael Eisenmann

This tutorial will show attendees an overview of the benefits of using DOC v4 /DecisionsBrain Gene to generate, build and run a complete application in minutes by: • Defining the business data model (entities and relationships) that will be used inside the application) • Generating the application using the Gene Command Line Interface (CLI) The created application will include: • Predefined projects to support the micro-services that will constitute the application • Project build configuration files (Gradle, Docker) • Application deployment configuration files (docker-compose) it is ready to be built and can be run on a stand-alone laptop immediately.

2 - Map-Reduce for Optimization: Build and Deploy Optimization Decomposition on Distributed Resources in the Cloud

Filippo Focacci, Decision Brain, 18 rue Yves Toudic, Paris, 75010, France

DecisionBrain Optimization Server (DBOS) seamlessly runs multiple CPU intensive computational jobs locally or remotely and provides administrative tools to easily monitor and manage them. Specifically designed to help build and deploy fully scalable optimization applications, it enables optimization developers to easily design parallel and distributed decomposition methods and large neighborhood search methods. In this workshop, we demonstrate how this technology can be used to solve a large-scale optimization problem by mimicking, in a very simple way, a Map-Reduce type of approach: split the problem into sub-problems, solve each sub-problem on a different distributed resource, and eventually, combine the different results.

■ WA59

CC- Chelan 2

Statistical Modeling and Inference in Smart and Connected Systems

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Changyue Song, Madison, WI, 53715, United States

Chair: Kaibo Liu, University of Wisconsin-Madison, Madison, WI, 53706, United States

1 - Identifying the Influential Inputs for Network Output Variance Using Sparse Polynomial Chaos Expansion

Zhanlin Liu, University of Washington, Seattle, WA, 98105, United States, zhanlliu@uw.edu, Ashis Banerjee, Youngjun Choe

Sensitivity analysis aims to identify system inputs that most influence the variance of system output. Existing approaches typically take the input-output relationship as a black-box and conduct extensive Monte Carlo sampling to identify influential inputs. For a class of input-output relationships expressed as directed acyclic networks, this study proposes a novel model that requires much fewer observations than Monte Carlo sampling to accurately identify influential inputs. Asymptotic properties of the model are established and two manufacturing examples are implemented for validation.

2 - Real-time Quality Monitoring of Supply Chains with Perishable Products

Weihong (Grace) Guo, Rutgers, The State University of New Jersey, Piscataway, NJ, 08854, United States, wg152@rutgers.edu, Mark Rodgers

This study focuses on the real-time monitoring and control of the quality of perishable products to mitigate against degradation as they are transported throughout a smart and connected supply chain network. Given the rising number of food waste and safety scandals in recent years, the quality of perishable products has important implications. In this work, environmental conditions and product quality characteristics are recorded during the transportation journey. These data are modeled to predict residual shelf life for any given conditions of the journey, which will help optimize the future journey in order to ensure an acceptable residual shelf life when the products reach its destination.

3 - Transfer Learning Between Material Systems for Laser Based Additive Manufacturing

Linkan Bian, Mississippi State University, Industrial and Systems Engineering Department, Mississippi State University, MS, 39762, United States, bian@ise.msstate.edu, Jack Francis, Arman Sabbaghi, Ravi Shankar, Morteza Ghasri-Khouzani

Distortion in additive manufacturing is a critical issue that adversely affects the geometric integrity of additively manufactured products. Current methods for investigating the distortion behaviors of different material systems typically involve Finite Element Analysis or a large number of experiments in an empirical study. We propose a Bayesian model transfer methodology that is both physics-based and data-driven to leverage past experiments on previously studied material systems for more efficient distortion modeling of new systems. We validate our methodology in a case study of distortion model transfer from Ti-6Al-4V disks to those manufactured using 316L stainless steel.

4 - Machine Learning and Artificial Intelligence for Long-term Fault Prognosis in Complex Manufacturing Systems

Kahkashan Afrin, Texas A&M University, College Station, TX, 77840, United States, afrin@tamu.edu, Satish Bukkapatnam, Darpit Dave, Soundar Kumara

Recent advances in sensors and streaming data sources of plant floor information systems open an exciting possibility to predict the fault risks over much longer time horizons than what was conceivable before. This work introduces a Manufacturing System-wide Balanced Random Survival Forest (MBRSF), a nonparametric machine learning approach that can fuse complex dynamics underlying these data streams to provide long-term fault prognosis. Experimental investigations with a 20 machine automotive manufacturing line suggest that MBRSF reduces prediction errors by over 90% compared to other contemporary methods.

■ WA59a

CC- Chelan 3

Applied Probability

Contributed Session

Chair: Zhengyu Zhang, University of Southern California

1 - Research on Multi-stage and Multi-objective Production Planning Considering Decision Makers' Preference

Yanfeng Chu, Nanjing university of Aeronautics and Astronautics, Nanjing, China, yanfengc@nuaa.edu.cn

The purpose of the study is to resolve the problem on making production planning of the multi-product, multi-stage and small-batch products when information is uncertain. In this paper, the linear programming model of grey parameters is constructed. Compared with the traditional production planning optimization method, the effectiveness of the production planning is proved. The results will give a range of decision variables, and help decision makers arranging production planning to deal with unavoidable information uncertainty.

2 - Privately Detecting Changes in Unknown Distributions

Yuliia Lut, Georgia Institute of Technology, Atlanta, GA, United States, yuliia.lut@gatech.edu, Rachel Cummings, Sara Krehbiel, Wanrong Zhang

The change-point detection problem seeks to identify distributional changes in streams of data, and is increasingly studied in settings where data may be highly sensitive. Differential privacy is a powerful technique for enabling data analysis while preventing privacy leakage. All prior work on private change-point detection requires complete knowledge of the pre- and post-change distributions, but this assumption is not reasonable in practice. We develop differentially private algorithms for solving the change-point problem when the distributions of data are unknown. We also apply our algorithms to detect changes in the linear trends in data streams that change smoothly over time.

3 - Differentially Private Change-Point Detection

Wanrong Zhang, Georgia Institute of Technology, Atlanta, GA, United States, Sara Krehbiel, Rui Tuo, Yajun Mei, Rachel Cummings

The change-point detection problem seeks to identify distributional changes at an unknown changepoint k in a stream of data. This problem appears in many important practical settings involving personal data, including biosurveillance, fault detection, nance, signal detection, and security systems. The eld of dierential privacy oers data analysis tools that provide powerful worst-case privacy guarantees. We study the statistical problem of change-point detection through the lens of dierential privacy. We give private algorithms for both online and oine change-point detection, analyze these algorithms theoretically, and provide empirical validation of our results.

4 - Analysis and Forecasting of Mass Shootings Using Change Point Detection

Cameron MacKenzie, Iowa State University, 3029 Black Engineering, Industrial and Manufacturing Systems Eng, Ames, IA, 50011, United States, Xue Lei

The frequency with which active or mass shootings occur in the United States is increasing in each year. This research conducts statistical analysis on historical data to forecast the number of active or mass shootings occurring in the United States. Change point detection can be applied to historical mass shootings to understand how the frequency of shootings has changed over time. Change point detection also enables us to forecast how the number of shootings will change during the future. The results of this research can contribute to improving laws, preventing mass shootings, and responding to them.

5 - A Stochastic Assignment Problem with Unknown Eligibility Probabilities

Zhengyu Zhang, University of Southern California, Los Angeles, CA, United States, zhan892@usc.edu, Sheldon M. Ross, Gideon Weiss

Consider n initially empty boxes, numbered 1 through n. Balls arrive sequentially. Each ball has a binary vector I = (I1,...,In) attached to it, with the interpretation that the ball is eligible to be put in box i if Ii = 1. An arriving ball can be put in any empty box for which it is eligible. Assuming that components of the vectorare independent Bernoulli random variables with initially unknown probabilities pi = P(Ii= 1), i = 1, ..., n, our primary interest is to compare several policies to determine which leads to a stochastically smaller number of observed balls until all boxes are filled.

■ WA60

CC- Chelan 4

Non-parametric Modeling, Monitoring and Control for Complex Systems

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Chao Wang, University of Wisconsin Madison, University of Wisconsin Madison, Madison, WI, 53706, United States

1 - Stochastics Prognostics under Multiple Time Varying Stress Factors

Salman Jahani, University of Wisconsin-Madison, Department of Industrial/Systems Engineering, Madison, WI, 53706, United States, jahani@wisc.edu, Shiyu Zhou, Dharmaraj Veeramani

In this study, we present a new multilevel modelling framework for sensor-based degradation signals that predicts, in real time, the residual life time of individual components subject to a time varying environment. Unique to our methodology, additive effects of multiple time varying stress factors influences the degradation of individual components. The proposed framework updates degradation model and the residual life distribution of the components by combining the historical data with real-time sensor-based data through a Bayesian approach.

2 - Spatial-temporal Modeling of Cardiac Electrical Activity Based on Gaussian Process and Mechanistic Model

Zhiyong Hu, Texas Tech University, TX, 79415, United States

This study integrates Gaussian Process (GP) with electrophysiological model of cardiac tissue to provide an accurate estimation of spatial temporal variations of cardiac action potential. Specifically, the spatial temporal propagation of action potential is described using a GP, where the mean is modeled by a 2D reaction-diffusion model, and the covariance captures the correlation of model discrepancy in both temporal and spatial domains. The reaction-diffusion and the GP models are calibrated simultaneously using a small set of observations to identify optimal parameters. The hybrid model can significantly reduce computational time, thus has great potentials for practical applications.

3 - Functional Principal Component Analysis for Extrapolating Multi-stream Longitudinal Data

Seokhyun Chung, University of Michigan, Ann Arbor, MI, United States, seokhc@umich.edu, Raed Al Kontar

We propose a functional principal component (FPC) analysis based approach to predict the evolution of multi-stream longitudinal data for an in-service unit based on other historical units. Our approach first decomposes each stream into eigenfunctions and corresponding FPC scores. A Gaussian process prior for the FPC scores is then established based on a semi-metric measuring similarities between streams of historical units and the in-service unit. Finally, an empirical Bayesian updating strategy is derived to update the prior using real-time data obtained from the in-service unit. Strengths of the model are illustrated through numerical studies using synthetic and real-world data.

4 - Approximate Multivariate Distribution of Key Performance Indicators through Ordered Block Model and Pair-copula Construction

Chao Wang, University of Iowa, Iowa City, IA, 53706, United States, cwang436@wisc.edu

We propose to use ordered block model and pair-copula construction (OBM-PCC) to approximate the multivariate distribution of Key Performance Indicators (KPIs). The KPIs are treated as random variables in the OBM and studied under the stochastic queuing framework. The dependence structure of the OBM represents the influence flow from system inputs to KPIs. Based on the OBM structure, the PCC is employed to approximate the joint distribution represented by KPIs and quantify the KPI values. The OBM-PCC model removes the redundant pair copulas in traditional modeling, and enjoys the flexibility and analytical properties in KPI modeling, thus efficiently providing the accurate approximation.

■ WA61

CC- Chelan 5

Recent Advances in Data Science for Computer Simulations

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Rui Tuo, College Station, TX, 77845, United States

1 - Gaussian Process Model Assisted Active Learning of Physical Laws

Lulu Kang, Associate Professor, Illinois Institute of Technology, Chicago, IL, 60616, United States, lkang2@iit.edu, Jiuhai Chen, Guang Lin

Discovering the governing equations from noisy data is an essential challenge in many areas of science and engineering. However, in many cases, experimental data are costly or time-consuming to obtain. This article provides an active learning approach to estimate the underlying PDE and ODE models. We propose an adaptive design criterion combining the D-optimality and the maximin space-filling criterion, and use the Gaussian process model and its derivatives to substitute the unknown functions and their derivatives. Variable-selection-based regression methods are used to learn the PDE or ODE models. The proposed active learning approach is entirely data-driven.

2 - A Clustered Gaussian Process Model with an Application to Solar Irradiance Emulation

Chih-Li Sung, Michigan State University, East Lansing, MI, 48824, United States, sungchih@msu.edu

A Gaussian process has been one of the important approaches for emulating computer simulations. However, the stationarity assumption for a Gaussian process and the intractability for large-scale dataset limit its availability in practice. In this article, we propose a clustered Gaussian process model which segments the input data into multiple clusters, in each of which a Gaussian process is performed. The stochastic expectation-maximization is employed to efficiently fit the model. In a simulation as well as a real application, our prediction had smaller mean square error than its main competitors, with competitive computation time.

3 - Uncertainty Quantification for Bayesian Optimization

Wenjia Wang, SAMSI, Durham, NC, 27713, United States, 1992wangwenjia@gmail.com, Rui Tuo

In this work, we propose a novel approach to assess the output uncertainty of Bayesian optimization algorithms, in terms of credible regions for the maximum value and the maximizer of the objective function. These regions can be computed efficiently, and the credible levels of these regions are guaranteed by newly developed uniform error bounds for Gaussian process regression. Our theory provides a unified uncertainty quantification framework for all sequential sampling policies in Bayesian optimization and arbitrary stopping criteria.

■ WA62

CC- Tahoma 1

Empirical Study in Substance Misuse

Sponsored: Health Applications

Sponsored Session

Chair: Qiushi Chen, Penn State University, University Park, PA, 16802, United States

1 - The Impact of Substance Abuse Treatment Services Facilities in Combating the Opioid Epidemic

Liang Xu, Pennsylvania State University, 419A Business Building, Penn State University, State College, PA, 16801, United States, lzx103@psu.edu, Hui Zhao

Despite better treatments play a central role in combating the opioid epidemic, fewer than 10% of these patients are receiving these treatments. The low prevalence of treatments is largely due to the lack of access to treatment facilities. We investigate how an increased supply of treatment facilities could help to combat the epidemic, and find that, on average, a 1% increase in the number of treatment facilities in a state leads to a 1.848% decrease in the overdose death rate, as well as a 2.083% decrease in the opioid-related ED visit rate in the state. Furthermore, the increase of SATS facilities with MAT services is more effective in reducing opioid overdose death rate than the ones without MAT services.

2 - Analyzing Recent Trend of Massachusetts Opioid Prescribing Patterns Leveraging All Payer Claims Data

Muhammad Noor-E-Alam, Northeastern University, Boston, MA, MA 02115, United States, md.alam@neu.edu

This study, as part of an ongoing research investigates the recent trend of prescription opioids dispensed for Massachusetts residence. Results showed an increasing trend in the prescribing of suboxone—an opioid largely prescribed for managing opioid addiction. Such drug level analysis in different geographic regions by leveraging Massachusetts All Payer Claims Data (MA APCD) provides promising insights that can be exploited to design interventional strategies to combat opioid crisis.

3 - Opioid Related Adverse Drug Reactions Prediction with Machine Learning

Soundar Kumara, Pennsylvania State University, University Park, PA, United States, Dolzodmaa Davaasuren

Opioid analgesics are widely used in the treatment of chronic, cancer and non-cancer related pain. In the recent years, the opioid epidemic has evolved rapidly, starting with an increase in opioid prescription. Based on the FDA Adverse Event Reporting Data, we performed extensive investigation on the opioid related adverse events in terms of patients' demographic, disease and other commonly prescribed drugs along with opioids. Also, we propose a machine learning algorithm for predicting adverse reaction and outcome resulting from the potential interaction among prescribed drugs for the disease and opioids.

4 - Extracting Meaningful Features from Transaction Data

Ryan Sanders, University of Arkansas, Cave City, AR, United States, rpsander@uark.edu, Shengfan Zhang, Art Chaovalitwongse

The goal of this project is to develop an efficient methodology for extracting features from time-dependent variables in transaction data. Transaction data is collected at varying time intervals making feature extraction more difficult. Supervised representational learning techniques are investigated, and the results compared with those from other feature engineering techniques. This methodology is then applied to insurance claims data in order to find features to predict whether a patient is at risk of overdosing on opioids. This data covers prescription, inpatient, and outpatient transactions.

5 - Drug Arrests and Overdose Outcomes of Substance Abuse

Qiushi Chen, Pennsylvania State, University Park, PA, 16802, United States, Glenn Sterner, Joel Segel

To combat the opioid crisis, state and federal governments have implemented different policies, such as prescription drug monitoring programs and "pill mill" laws, which primarily focus on curbing the supply of prescription opioids. But less is known about supply of illicit substances, which is also a critical factor that has been fueling the epidemic. In this study, we collect illicit drug arrest data from an incident-based reporting system used by law enforcement agencies in the United States to describe the illicit drug availabilities, and examine the association between drug criminal activities and health outcomes including healthcare utilization and overdose death.

■ WA63

CC- Tahoma 2

Scheduling in Healthcare Operations

Sponsored: Health Applications

Sponsored Session

Chair: Jin Qi, Hong Kong University of Science and Technology, Hong Kong University of Science and Technology, Hong Kong, Hong Kong

1 - Medical Appointment Overbooking and Optimal Scheduling

Yong-Hong Kuo, Assistant Professor, The University of Hong Kong, Dept. of Industrial and Manu. Sys. Eng., Pokfulam Road, Hong Kong, yhkuo@hku.hk, Hari Balasubramanian, Yan Chen

We propose a framework that utilizes a stochastic mixed-integer linear program for guiding scheduling decisions under a simulation environment. With this framework, we conduct a comprehensive analysis of the tradeoffs between schedule efficiency and accessibility to service. Our computational experiments suggest that a session capacity approximate to the request rate can balance the multiple conflicting objectives more effectively; a fixed capacity policy can be as effective as a dynamic overbooking policy under the setting of a constant request rate; and a dynamic overbooking policy leads to a slightly better performance under the setting of a non-homogeneous appointment request rate.

2 - When to Triage in Service Systems with Hidden Customer Class Identities?

Zhankun Sun, City University of Hong Kong, 7-268, 7/F, Academic 3, Tat Chee Avenue, Kowloon, Hong Kong, zhanksun@cityu.edu.hk, Sukriye Nilay Argon, Serhan Ziya

Motivated by patient triage, we consider a single server service system with Poisson arrivals and two types of jobs. The type identity of each job is initially unknown but can be revealed through triage. However, triage takes time and is error-prone. Hence, it is unclear when triage should be carried out. We formulate this problem as a Markov decision process and characterize the optimal policy on triage. We identify conditions under which triage should never be considered and when a state-independent policy performs sufficiently well.

3 - A Comparative Analysis of Scheduled- Versus Compassionate-dialysis for the Uninsured and Indigent

Farnaz Nourbakhsh, Southern Methodist University, Dallas, TX, 75243, United States, Olga Bountali, Sila Cetinkaya

Uninsured patients suffering from chronic diseases may have access to medical treatment under federal law, EMTALA, only after being evaluated as in ‘emergent, life-threatening condition’. In the case of ESRD patients who do not have access to regular treatment, the practice of offering dialysis conditional on a screening assessment in the ER is known as “compassionate dialysis”. In this paper, we pose the hypothetical question of “What if the uninsured ESRD patients had access to scheduled dialysis as an option?” Our goal is to offer a comparison of system and patient-centric performance criteria under the two options.

4 - Operating Theatre Scheduling under Uncertainty with an Entropic Index

Xiaojin Fu, Hong Kong University of Science and Technology, Clear Water Bay, Hong Kong, Hong Kong, xfuab@connect.ust.hk, Jin Qi, Han Ye

We consider a surgery sequencing and scheduling problem in the Operating Theatre. From the data, “to follow” policy is observed, in which surgeries are conducted one after another and can start earlier than the scheduled time. Under this policy, we propose a mathematical framework to balance the idle and waiting risk with the Inbound Index. To find the optimal sequence and scheduled starting times, we develop an efficient algorithm based on Benders Decomposition. Moreover, for its practical use, we propose heuristics for sequencing decisions based on surgical time’s standard, forward and backward deviations. We further propose numerical studies to show the benefit of the model and the heuristics.

■ WA64

CC- Tahoma 3

Healthcare Analytics in Emergency and Critical Care

Sponsored: Health Applications

Sponsored Session

Chair: Xiaolei Xie, Tsinghua University, Beijing, 100084, China

Co-Chair: Zhankun Sun, City University of Hong Kong, Kowloon, Hong Kong

1 - Dynamic Scheduling of Multi-priority Multi-class Patients with Wait Time Targets in a Tele-ICU: Case Study and Analysis

Xuanjing Li, Tsinghua University, ShunDe, Beijing, China, lixj15@mails.tsinghua.edu.cn, Dacheng Liu, Xiaolei Xie

This paper, motivated by the collaboration with a tele-ICU company, focuses on reducing the incidents of excessively long waits at any server in a tandem queue. We first conduct descriptive analytics of arrival data and service time of multi-priority multi-class patients. To improve the waiting time management, we consider the accumulating priority queue (APQ), where the priorities of patients are functions of their waiting time and initial class. Using empirical data from the tele-ICU company, we build simulation models to compare the performance of different scheduling policies, including policy derived from APQ, threshold-based policy and FIFS (First-In-First-Serve) policy.

2 - Who is Next: Dynamic Patient Prioritization in an Emergency Department

Wenhao Li, City University of Hong Kong, Kowloon, Hong Kong, wenhaoli6-c@my.cityu.edu.hk, Zhankun Sun, Jeff Hong

In the emergency department (ED), priority scores are assigned to patients at triage based on their acuity levels. However, using operational data from more than 150,000 patient visits, we find that doctors may deviate from this priority sequence, and within each priority class, patients may not be served in a first-come-first-serve manner. Our analysis shows that when selecting the next patient to treat, doctors prioritize patients who are more likely to be discharged after treatment at ED when many ED beds are occupied by boarding patients, in an effort to avoid further access block to the ED.

3 - Scheduling of Physicians with Time-varying Productivity Levels in Emergency Departments

Marco Bijvank, University of Calgary, Calgary, AB, T2N 1N4, Canada, marco.bijvank@haskayne.ucalgary.ca, Farzad Zaerpour, Zhankun Sun

Traditionally, physicians are assigned to shifts based on preferences or other conditions like fairness or ergonomics. As a result, physicians are considered interchangeable. However, each physician has a different productivity (measured as the number of new patient assessments in an hour, or PPH rate). Ignoring the heterogeneity between physicians can lead to congested EDs. We show with a regression analysis that the PPH rate is a physician characteristic independent of the congestion level at the ED. Next, we solve the physician rostering problem with a two-stage stochastic program formulation, where we incorporate the stochastic nature of both patient arrivals and physician productivity.

4 - Physician Scheduling for Emergency Department with Time-varying and Stochastic Demand

Ran Liu, Associate Prof., Shanghai Jiao Tong University, Shanghai, China, liuran2009@sjtu.edu.cn, Xiaolan Xie

The patient arrival rates to emergency department (ED) during one day is strongly time-varying. Such fluctuation is one main cause of long waiting times, and ED staffing is one key driver of service quality improvement. Based on data from a large hospital of Shanghai, China, we model the service of ED as a non-stationary M(t)/M/C(t) queuing system. Based on Markov chain model and uniformization, system is analyzed and the physician scheduling problem is formulated as a MIP model. An heuristic algorithm is designed to the problem. Experiments show the algorithm has good performances. Compared with scheduling used in the hospital, our solution can reduce patient waiting time and physician working time.

5 - The Operational Effectiveness of a Full Capacity Protocol to Ease the Crowding at an Emergency Department

Lu Wang, University of Kansas, Lawrence, KS, 66045, United States, lu.wang@ku.edu, Mazhar Arikan, Suman Mallik

The Full Capacity Protocol (FCP) is a set of guidelines that coordinate the patients flow when the emergency department (ED) is overcrowded. Utilizing data from a large urban teaching hospital, we characterize its impacts on the operational performance of the ED.

■ WA65

CC- Tahoma 4

Decision and Data Analytics for Healthcare Service Operations

Sponsored: Health Applications

Sponsored Session

Chair: Zhan Pang, PhD, Purdue University, West Lafayette, IN, 47907, United States

1 - Discrete Convexity Results for Coordinated Scheduling for In-clinic and Virtual Medicine Patients in an Integrated Practice Unit

Douglas Morrice, University of Texas-Austin, IROM Department, Austin, TX, 78712-1750, United States, douglas.morrice@mccombs.utexas.edu, Jingyao Huang

Coordinated services and virtual medicine are two innovative concepts being employed in value-based, patient-centered care. In this paper, we develop discrete convexity results and heuristics for coordinated scheduling of both in-clinic and virtual medicine patients in an Integrated Practice Units (IPU). An IPU is a co-located, multi-disciplinary team of providers that delivers a full care cycle.

2 - Risk-sensitive Appointment Scheduling

Shuming Wang, University of Chinese Academy of Sciences, Beijing, China, wangshuming@ucas.edu.cn, Zhan Pang

We study a joint sequencing and scheduling problem with uncertain service times and multi-class patients in the framework of stochastic optimization with risk measures. We minimize the overtime risk and constrain the delay risk for each patient scheduled. We focus on the problem with the popular coherent risk measure CVaR. In particular, for the case of single-class of patients, we show the problem under CVaR measure is $L^\natural$-convex, which enables us to design polynomial time algorithms to solve the problem efficiently and practically. As for the multi-class case, we show that the problem in sample formulation can be transformed into a mixed integer linear program.

3 - Managing Quality of Care in Competitive Healthcare Markets: A Rational Expectations Equilibrium Approach

Linggang Qi, City University of Hong Kong, Hong Kong, China, lingganqi2-c@my.cityu.edu.hk, Zhan Pang, Sergei Savin

Our work investigates the effects of social learning on hospitals' quality decision in a competitive healthcare market. We consider a duopoly where hospitals are competing on quality, which may be inferred from online patients' reviews when it is unknown and patients are sensitive to quality-of-care, waiting times and traveling cost. We analyze the rational equilibrium behavior of patients and Nash equilibrium quality decisions of hospitals. We find that hospitals' quality decision is decreasing in traveling cost. Also, we find that hospitals' quality decision is decreasing with the accuracy of information that can be acquired by patients.

■ WA66

CC- Tahoma 5

Socially Responsible Supply Chains: Auditing and Competition

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Rodney Parker

Co-Chair: Han Zhang

1 - A Balancing Act of Regulating On-demand Ride Services

Jiayi Joey Yu, University of California, Berkeley, Berkeley, CA, 94720, United States, yujiayijoey@gmail.com, Christopher S. Tang

Regulating on-demand ride-hailing services requires a balance of multiple competing objectives. This study is motivated by a regulatory policy implemented by the Chinese government in 2017 and a similar policy approved by the New York City Council in 2018. We examine the impact of these policies on the welfare of different stakeholders. By analyzing a two-period dynamic game, we find that relative to no regulations and a complete ban policy, a carefully designed regulatory policy can strike a better balance of multiple competing objectives. Finally, if a government can reform the taxi industry by adjusting the taxi fare, then lowering the taxi fare can improve the total social welfare.

2 - Supplier Centrality and Auditing Priority in Socially-responsible Supply Chains

Jiayu Chen, The University of Texas at Dallas, Richardson, TX, 75080, United States, Anyan Qi, Milind Dawande

Most supply networks are characterized by firms that source from multiple suppliers and suppliers that serve multiple firms, thus resulting in suppliers who di er in their degree centrality, i.e., the number of firms they supply to. In such networks, negative publicity from suppliers' noncompliance of socially-responsibility can damage the buying firms' brand. To mitigate this, firms audit suppliers, although resource and time considerations restrict the number of audited suppliers. A key question is whether firms should prioritize the auditing of suppliers with low or high centrality. We explore how supplier centrality affects socially-responsible supply chains and offer useful insights.

3 - Supplier Audit Information Sharing and Responsible Sourcing

Yunjie Wang, Renmin University of China, Zhongguancun Street, Beijing, 100080, China, ywangbm@connect.ust.hk, Albert Y. Ha, Weixin Shang

We develop a game-theoretic model to study the incentive for competing manufacturers to share supplier audit information in a market with some consumers who boycott a manufacturer if supplier responsibility violations occur. Based on the audit information, each manufacturer either continues to source from an existing common supplier who has uncertain responsibility risk, orswitches to a new supplier who has no responsibility risk but charges a higher price. We characterize the manufacturers' equilibrium audit information sharing decisions and sourcing strategies, and show how they depend on the model parameters.

4 - Social Responsibility Auditing in Supply Chain Networks

Han Zhang, student, Indiana University Bloomington, Bloomington, IN, 47405, United States, hz8@iu.edu, Goker Aydin, Rodney P. Parker

We study a buyer's problem of auditing suppliers in a generalized three-tier supply network with the intention of verifying their social responsibility compliance. The buyer suffers economically if a non-compliant supplier's violation is exposed. To avoid such damages, the buyer dynamically chooses which suppliers to audit. If a supplier fails an audit, the buyer chooses whether to rectify the supplier or drop the supplier from the supply network entirely. Dropping a supplier (and its dependents) lessens the buyer's profit due to reduced competition. We characterize the price/quantity equilibrium of production activities in the supply network and the buyer's optimal auditing strategy.

■ WA67

S- Virginia

Supply Chain Management VII

Contributed Session

Chair: Chun Cheng, Polytechnique Montreal, Montreal, QC, H3S1T1, Canada

1 - The Impact of Relative Performance in a Supply Chain with Multiple Retailers

Xifei Liu, Peking University, Beijing, China, liuxifei@pku.edu.cn, Shuxiao Sun

This paper studies the impact of relative performance (RP) on the equilibrium quantities and profits in a supply chain consisting of one manufacturer and multiple retailers. The manufacturer decides the wholesale price and the retailers engage in quantity competition. We assume that some of the retailers have relative preferences when they make their decisions, i.e., maximizing a weighted sum of profits and their relative performances.

2 - Strategic Overcapacity in Platform Selling under Asymmetric Information

Liqun Wei, Tianjin University, Tianjin, China, lqwei@tju.edu.cn, Jianxiong Zhang

In this paper, we study the optimal capacity strategy of manufacturer who sells product on platform. The platform has the leadership of pricing and more demand information about the market. We build a signaling game model where the manufacturer can learn the demand information disclosured from the platform's commission fee decision to more properly set retail price, and investigate the interactions between the manufacturer's capacity decision and the retailer's signaling. Interestingly, we find that the manufacturer may strategically set the overcapacity decision, that is, he could gain more profit by investing in a high capacity level which always exceeds the actual demand.

3 - Learning Asymmetric Forecast Preferences in Supply Chain Forecast Sharing

Lin Zhao, Tsinghua University, Beijing, China, zhaolin14@mails.tsinghua.edu.cn

Forecast sharing has been widely adopted to coordinate production planning in supply chains. However, the effectiveness of forecast sharing can be hindered by forecast inflation caused by the forecaster's asymmetric preference toward over-and-under-forecast. We present two optimization models for the supplier to recover the asymmetric forecast preferences. We apply the models in a case study concerning a real-world forecast sharing practice in a PC manufacturing supply chain. The results show that there exists significant forecast inflation in the shared forecasts. We also investigate the supplier's benefit from learning the manufacturer's forecast preference.

4 - How National Culture Moderates the Effect of Supply Chain Integration on Flexibility Performance: Evidence from Multi-country Data

Jing Tan, Xi'an Jiaotong University, Xi'an, China, xjtutj@stu.xjtu.edu.cn, Shan Liu, Hongyi Mao, Jinlong Zhang, Yajun Zhang

Although global supply chain (SC) is widespread, the role of national culture in SC management is poorly understood. This study examines how the effect of SC integration on flexibility performance is contingent on critical national culture dimensions. Based on 121 pair-wised survey data from SC managers and senior managers of retail firms from 31 countries, results corroborate that SC integration has a positive effect on the flexibility performance of firms. Such effect decreases in individualism but increases in high uncertainty avoidance culture. Our findings contribute to the literature to global SC management by integrating the contingency view and cultural perspective.

5 - A Process View on Managing Supply Chain Disruptions

Iana Shaheen, University of South Florida, Tampa, FL, United States, ianalukina@usf.edu, Arash Azadegan, Kevin Linderman

Viewing a major SC in disruption as an organizational change process, we develop and test a series of propositions. First, we look at patterns of leadership behavior during 41 SC disruptions in the supply network of a global automotive firm. Second, we use vignette-based experiments to offer support for some of the propositions developed in the first study.

6 - Robust Facility Location under Disruptions

Chun Cheng, Polytechnique Montreal, Montreal, QC, Canada, chun.cheng@polymtl.ca

We study a fixed-charge location problem that considers the risk of disruptions. We adopt a two-stage robust optimization method, where facility location decisions are made here-and-now and recourse decisions to reassign customers are made after the uncertainty information on the facility availability has been revealed. We implement a column-and-constraint generation algorithm to solve the robust models exactly. We further develop an approximation scheme for instances of a realistic size; it requires the adjustable decisions to be an affine function of the uncertain parameters.

■ WA68

S- University

Manufacturing I

Contributed Session

Chair: Changqin Yin, Huazhong University of Science and Technology, Hongshan District, Wuhan, China

1 - Towards Next Generation of Manufacturing Smart Devices - Insights from Customer Reviews

Suchithra Rajendran, University of Missouri, Columbia, MO, United States, suchithra.rajendran@gmail.com, Emily Pagel

In the era of web 2.0, with the introduction of smart devices, consumers are inviting technology into their home in pursuit of a more efficient lifestyle. Although these gadgets' performances are quite impressive, there remains a need for continuous improvement. To fully evaluate the market's perception of each applicable smart device, in this study, text analytics tools were used to analyze customer reviews and perform SWOT analysis. Based on our analysis, several next-generation manufacturing design insights are provided that can be adapted by most of the smart devices.

2 - A Machine Learning Approach for Analyzing Microstructure on Fiber Reinforced Materials

Zimo Wang, Texas A&M University, College Station, TX, United States, zimowang@tamu.com

Natural Fiber reinforced Plastic (NFRP) composites offer tremendous ecological advantages for sustainable manufacturing because of their degradability and recyclability. However, the heterogeneity of the NFRP leads to variations of material removal mechanisms over time which adversely impacts the surface finish. We present an in-process monitoring approach for characterizations for machining Natural Fiber Reinforced Plastic (NFRP) materials manufacturing processes. The presented machine learning approach allows the estimation of the localized fiber packing density (FPD) and resultant the surface integrity using extracted features from implemented sensors.

3 - The Impact of Patents on American Manufacturing Productivity

Anand Kandaswamy, Economist, NIST, Washington, DC, United States, anand.kandaswamy@nist.gov

The economics literature on the topic of productivity stresses the importance of innovation along with traditional factors like capital and labor investments. Using patents activity as a proxy for innovation, we statistically model just how important innovation is in driving gains in certain key American manufacturing industries.

4 - The Impact of IT Investment and Worker Composition on Manufacturing Worker Productivity: The Moderating Effect of IT Usage

Changqin Yin, Huazhong University of Science and Technology, Wuhan, China, yinchangqin2015@163.com

In this study, two types of manufacturing enterprises with significant differences in the use of IT were selected to examine the impact of IT investment and worker composition on worker productivity. The results show that in enterprises with a high degree of IT use, IT investment positively impact worker productivity, the decrease of professional and civilian worker has a positive effect on the improvement of worker productivity, while the decrease of managerial worker negatively impacts worker productivity. In a manufacturing company with a low level of IT use, the result is the opposite.

■ WA69

S- Seneca

Telecommunications and Network Analytics II

Sponsored: Telecommunications and Network Analytics

Sponsored Session

Chair: Michael Bartolacci, Penn State Berks, Bethlehem, PA, 18017, United States

1 - Using Spreadsheet Maps for the Optimal Placement of Low Altitude Platform (LAP) Wireless Network Nodes for Disasters

Michael Bartolacci, Professor of Information Sciences and Technology, Penn State University - Berks, Reading, PA, 18017, United States, mbartolacc@aol.com, Larry J. LeBlanc, Thomas A. Grossman

Low Altitude Platform (LAP) architectures are an emerging architecture platform for providing wireless network connectivity to areas with a damaged fixed wireless network infrastructure. The most common reason for such damage is weather-related, but could also be due to terrorism, sabotage, or human errors. The authors propose a spreadsheet-based approach for practitioners to locate LAP nodes in the field. We suggest a new spreadsheet-based approach that will appeal to practitioners by providing graphical visualizations of potential solutions.

2 - Optimization of the Supply Chain in Healthcare

Albena Mihovska, Associate Professor, Aarhus University BSS, Birk Centerpark 15, Herning, 7400, Denmark, amihovska@btech.au.dk, Alexander Bødker Andersen

Disruptive innovations through the digitalization of processes and emerging new technologies are all part of the fourth industrial revolution - called Industry 4.0. This research focuses on the potential impact and benefits Industry 4.0 could cause in the supply chain for a large Danish healthcare technology company. The research is conducted as an explorative case study which investigates how the transportation and implementation of high-technological and complex healthcare technology in the Danish hospitals can be mapped and potentially optimized. Furthermore, is it analyzed how Industry 4.0 concepts and technologies can be utilized by the company in a cost-efficiency perspective.

3 - Purposeful Internet Use in the United States: Geodemographics of Internet Access, Use, and Impact

Avijit Sarkar, University of Redlands, Redlands, CA, United States, avijit_sarkar@redlands.edu, James B. Pick

As internet penetration rates have steadily increased in the United States across dimensions such as education, gender, age, race/ethnicity, income, and employment, the span of purposeful internet usage has diversified as well. This paper examines socioeconomic aspects and geographic patterns of purposeful internet use in US states for hedonic and non-hedonic, contemporary activities such as engaging in e-commerce, e-health, and telework. Implications for the US digital divide are discussed, in light of an increasing focus on digital innovation driven by a sophisticated digital workforce.

■ WA70

S- Jefferson A

Finance Theory and Empirics

Contributed Session

Chair: Norio Hibiki, Keio University, Fac of Sci & Tech, 3-14-1 Hiyoshi Kohoku-Ku, Yokohama Kanagawa, 223-8522, Japan

1 - War and Peace in the Boardroom: Pre-vote Communication, Herding Behavior, and Boardroom Politics

Hang Sun, Dongbei University of Finance and Economics, Dalian, China, hang.sun@dufe.edu.cn, Di Feng

Please check the mobile app for this abstract.

2 - Share Repurchases and Market Returns

Hariprasad Bellamkonda, Associate Professor, IIM Indore, Indore, India, hariprasad@iimidr.ac.in

The investor reaction to actual share repurchases is examined in the Indian context. It is observed that the firms engage in buybacks when the share price exhibit a declining trend, consistent with price support hypothesis. The price patterns around share repurchases by smaller firms is consistent with signalling the undervaluation. When the percentage of share buyback is low, the results however confirm the price support hypothesis.

3 - Adjusted Portfolio Selection Model Reflecting the End of the Year Effect of Global Economic Growth

Jihye Yang, Yonsei University, Seoul, Korea, Republic of, jihyeyang89@gmail.com, Hongseon Kim, Seongmoon Kim

This study suggests improved investment strategy based on Markowitz's portfolio selection model reflecting the End-of-the-Year Effect. The proposed model includes additional constraints reflecting GDP adjusting the proportion of capital invested in risk assets and risk-free assets according to end of the year global economic growth. We empirically evaluate the performance of the proposed model in U.S, Germany, Korea, and Hong Kong stock markets. The proposed model achieved substantially higher returns, lower risk, and thus superior Sharpe ratio and Rachev ratio compared with other benchmarks.

4 - Dynamic Portfolio Selection with Linear Control Policies for Coherent Risk Minimization

Yuichi Takano, University of Tsukuba, Tsukuba, Japan, ytakano@sk.tsukuba.ac.jp, Jun-ya Gotoh

This talk is concerned with developing a linear control policy for dynamic portfolio selection where a coherent risk measure is minimized. We formulate this problem as a scenario-based optimization model. We then apply robust optimization techniques to our optimization model to improve the out-of-sample investment performance. Specifically, we prove that the worst-case coherent risk measure can be decomposed into the empirical risk measure and the regularization term. The efficacy of our method is assessed through numerical experiments with historical data on actual stock returns.

5 - Asset Allocation Model Using Asset-class-based and Factor-based Risk Parity Approaches

Norio Hibiki, Professor, Keio University, Yokohama, Japan, hibiki@ae.keio.ac.jp, Hirotaka Kato

In recent years, the risk parity strategy has become attractive to academics and practitioners. We propose a methodology of constructing the well-balanced portfolio by the mixture of asset-class-based and factor-based approaches. We also show the method of determining the weight of two approaches using the diversification index. We examine the characteristics of the model through the numerical tests with seven financial indices and three factors. We implement the backtest from 2005 to 2018, and the performances are measured on a USD basis. We find our method decreases risks, and it has a higher Sharpe ratio than other portfolio strategies. The results show our new method has practical advantages.

■ WA71

S- Jefferson B

Behavioral Queuing Science

Sponsored: Behavioral Operations Management

Sponsored Session

Chair: Kenneth Schultz, Xenia, OH, 45385, United States

1 - Last Place Aversion in Queues

Ryan Buell, Harvard Business School, Boston, MA, 02163, United States, rbuell@hbs.edu

Every line has an end, and with it, a person who is in last place. This paper documents the effects of last place aversion in queues on customer experiences and behaviors, as well as for operating performance. The results demonstrate that last place aversion harms customer experiences and can lead to maladaptive behaviors - switching that increases wait times, and abandoning when the benefits of waiting are most pronounced. The paper also documents the detrimental effects of last place aversion for queuing capacity. When the effects of last place aversion are addressed, overall abandonment decreases, such that with equivalent arrival and service rates, total service capacity can be increased.

2 - Structural Estimation of Intertemporal Externalities on ICU Admission Decisions

Fanyin Zheng, Columbia University, Columbia Business School, New York, NY, 10027, United States, Yiwen Shen, Carri Chan

The Intensive Care Unit (ICU) in a hospital often has the highest cost and the highest congestion level. Our study focuses on the intertemporal externalities in physicians' ICU admission decisions and their impact on patient outcomes and system performance. In particular, we study how admitting a patient in the current period affects the system status, and, in turn, its ability in admitting another patient with possibly more severe conditions in the next period. We take the structural estimation approach which allows us to estimate how much the physicians internalize the intertemporal externalities in their decision making from data.

■ WA72

S- Columbia

Economic Value of Digital Platforms and Artificial Intelligence

Sponsored: Information Systems

Sponsored Session

Chair: Shan Huang, University of Washington, Seattle, WA, 98195, United States

1 - The Value of Artificial Intelligence in Drug Development

Bowen Lou, University of Pennsylvania, Philadelphia, PA, United States, Lynn Wu

We examine how artificial intelligence (AI) can influence the drug development process. Despite an enormous amount of time and financial resources invested in developing drugs, pharmaceutical firms experience declines in novelty for drugs they produced. As AI becomes an important general purpose technology (GPT), it could be used to address some known challenges in the drug development process. Using a number of large-scale datasets that contain detailed historical records of global patents as well as drug development, we identify firms' AI capabilities and construct a relatively new metric to measure drug novelty, based on a novel backtracking graph matching algorithm to pinpoint the maximum common substructure in chemical graph representations of drugs. By differentiating multiple stages in the drug development process, we investigate where AI is most effective in developing new drugs. We find that AI can primarily affect the earliest stage in drug discovery when tasks are heavily dependent on automatic data processing and reasoning. However, it may not necessarily help with the more expensive and risky clinical trial stages that require substantial human engagements and interventions. Additionally, AI can facilitate the development for drugs at the medium level of chemical novelty but is not helpful with drugs at the extreme ends of the spectrum, those that are entirely novel or incremental me-too drugs. Our study sheds light on the understanding of the roles and limitations modern technology can have on drug development, one of the most complex innovation processes in the world.

2 - GDP-B: Accounting for the Value of New and Free Goods in the Digital Economy

Avinash Collis, Massachusetts Institute of Technology, Cambridge, MA, United States, Erik Brynjolfsson, Erwin Diewert, Felix Eggers, Kevin Fox

The welfare contributions of the digital economy, characterized by the proliferation of new and free goods, are not well measured in our current national accounts. We derive explicit terms for the welfare contributions of these goods and introduce a new metric, GDP-B which quantifies their benefits, rather than costs. We apply this framework to several empirical examples including Facebook and smartphone cameras and estimate their valuations through incentive-compatible choice experiments. For example, including the welfare gains from Facebook would have added between 0.05 and 0.11 percentage points to GDP-B growth per year in the US.

3 - The Contagion of Online Gift Giving

Yuan Yuan, Massachusetts Institute of Technology, Cambridge, MA, 110819, United States, Tracy Liu, Chenhao Tan, Jie Tang, Alex Pentland

Pay-it-forward behavior is a type of contagion of prosocial behavior. Existing empirical evidence of pay-it-forward behavior has been largely based on laboratory experiments, which are limited in sample size and external validity. Extending this research, our study uses a natural experiment to examine pay-it-forward reciprocity in a real-life context with a large-scale dataset of 3.4 million users of an online platform. Our natural experiment is enabled by the randomness in the mechanism that WeChat, a Chinese online social networking platform, uses to split an online monetary gift (also known as a "red packet") to its recipients. Our results show that recipients on average pay forward 10.34% of the amount they receive. We further find that "luckiest draw" recipients, or those who obtain the largest shares of their corresponding red packets, are 1.5 times more likely to pay it forward than other recipients. Our analyses indicate that in a multiple recipient setting, users' pay-it-forward behavior is enforced by a group norm that luckiest draw recipients should send the first subsequent gift and promoted by their distributional social preferences of the random amounts split by the platform. Finally, our study shows that those recipients without any in-group friends do pay it forward, even though their pay-it-forward behavior is less likely to be driven by their reputational concerns among acquaintances. Overall, our work provides insights into mechanisms and conditions that encourage pay-it-forward reciprocity, which have implications for fostering prosocial behavior.

4 - Spillovers in Digital Advertising

Sinan Aral, Massachusetts Institute of Technology, Cambridge, MA, United States, Michael Zhao

Please check the mobile app for this abstract.

■ WA73

S- Boren

Escape from the Ivory Tower / Wisdom Bank

Sponsored: INFORMS Section on Practice

Sponsored Session

Chair: Kenneth E Murphy, Chapman University, Chapman University, Orange, CA, 92866-1005, United States

1 - Moderator

Kenneth E. Murphy, University of California Irvine, 1 University Dr, Irvine, CA, 92866-1005, United States, murphyke@uci.edu

We often refer to academia as the Ivory Tower ... but what happens when professors leave universities and take jobs in industry? Or what about when perfectly good industry professionals take academic jobs? Or when retirees teach part-time as the Wisdom Bank? Our panel contains people who have made these career transitions, crossing the divide between academia and industry. Hear about what surprised them, why they made their changes, and who knows? Maybe you will find yourself with a career change as well.

2 - Bringing Industry and Consulting Experience to the Classroom.

Patrick E. Leach, Adjunct Professor / Independent Consultant, Colorado School of Mines, 1956 Lawrence St Apt 310, Denver, CO, 80202, United States, leach.sullivan@gmail.com

Panelists

- Don N. Kleinmuntz, Principal, Kleinmuntz Associates, Chicago, IL, 60614, United States, don@kleinmuntzassociates.com
- William Christian, 1214 Somerset Road, Severn, MD, 21144, United States
- Kenneth E. Murphy, University of California Irvine, Irvine, CA, 92866-1005, United States, murphyke@uci.edu

Edward Cook, President, The Change Decision, Richmond, VA, 23230, United States, ed.cook@thechangedecision.com

■ WA74

S- Capitol Hill

Auctions/Mechanism Design

Contributed Session

Chair: Wei Chen, University of Kansas, Lawrence, KS, 66049, United States

1 - Truthful Mechanisms for Location Games of Dual Role Facilities

Minming Li, City University of Hong Kong, Hong Kong, Hong Kong, minming.li@cityu.edu.hk, Xujin Chen, Changjun Wang, Chenhao Wang, Yingchao Zhao

This paper is devoted to the facility location games with payments, where every agent plays a dual role of facility and customer. In this game, each selfish agent is located on a publicly known location in a metric space, and can allow a facility to be opened at his place. But the opening cost is his private information and he may strategically report this opening cost. Besides, each agent also bears a service cost equal to the distance to his nearest open facility. We are concerned with designing truthful mechanisms for the game. The objective is to minimize (exactly or approximately) the social cost (the total opening and service costs) or the maximum agent cost of the outcome.

2 - Value Mutation and the Information Disclosure in Sponsored Search Advertising

Yun Zhou, School of Management, Zhejiang University, Hangzhou, China, zhouyun2015@zju.edu.cn, Weihua Zhou, Mingzheng Wang

In Sponsored Search Advertising (SSA), ad slots placed at higher rank may mysteriously possess lower click value than those at lower rank. This phenomenon, defined as Value Mutation (VM), will fairly distorts advertisers' bidding behavior. Using a game-theoretic model, this study thoroughly investigates the impact of VM and propose insights for Search Engine. A Decision Tree of Search Engine is constructed sequentially including disclosure of VM's information and VM modification. Search Engine always prefers to release the information. Counterintuitively, Search Engine is probably favored by the existence of Value Mutation, under specified conditions.

3 - Information Platforms for Congestible Goods

Hamidreza Tavafoghi, University of California-Berkeley, Berkeley, CA, United States, tavaf@berkeley.edu, Akhil Shetty, Kameshwar Poolla, Demosthenis Teneketzis, Pravin Varaiya

We study information disclosure mechanisms for congestible goods with unknown (uncongested) valuations. We show that a social planner can improve the outcome by providing either a public imperfect information signal about the goods' valuation or coordinated private recommendations to each agent. The welfare gain is increasing in prior uncertainty about the valuations and decreasing in the prior expected difference in the valuations. We consider two extensions of the basic model. First, we analyze the outcome in an environment with a single or multiple revenue-maximizing platforms. Second, we investigate the outcome in a dynamic two-step case where agents learn from their past experience.

4 - Optimal Periodic-Review Policies for Repeated Awards of Non-monetary Rewards

Wei Chen, Assistant Professor, University of Kansas, Lawrence, KS, United States, wei.chen@ku.edu, Milind Dawande, Ganesh Janakiraman

In practice, there are many situations where a principal reviews an agent's performance periodically, and awards him non-monetary rewards if his past performance is satisfactory at the time of each review. These non-monetary rewards motivate the agent to exert costly efforts to achieve good performance outcomes. Agent's efforts are not directly observable by the principal, while performance outcomes of the agent are directly observable. In this paper, using long-run average utilities as objectives, we study optimal period-review policies for the principal, and agent's best effort exertion under such policies.

■ WA75

S- Metropolitan Ballroom A

Flash Session VI

Flash Session

Chair: Mahdi Nasereddin, Penn State- Berks, Tulpehocken Road, Reading, PA, 19610-6009, United States

1 - Media Health Literacy Plays Critical Role of Shared Decision Making: Mediating Or Moderating?

Chi-Chang Chang, chungshan medical university, Taichung, Taiwan, changintw@gmail.com, Chalong Cheewakriangkrai, Ying-Chen Chen

Media health literacy have proven to be associated with health information seeking and with health literacy may be predicted by patient's Shared Decision Making. The mediation models and mediating hypotheses were tested by applying hierarchical multiple regression analyses. The finding suggests that e-health literacy has fully mediating effects between health literacy and shared medical decision making. Overall, it is important for health providers to consider the notion that more ehealth literacy may sometimes, but not always, be better.

2 - Model Exploration of an Information-based Healthcare Intervention Using Parallelization and Active Learning

Chaitanya Kaligotla, Postdoctoral Scientist, Argonne National Laboratory, Chicago, IL, United States, ckaligotla@anl.gov

This paper describes the application of a large-scale active learning method to calibrate a computational agent-based model developed to investigate the impact of a clinical information-based health intervention that provides patients with personalized information about local community resources to meet basic and self-care needs. The diffusion of information about community resources and their use, is modeled via networked interactions and their subsequent effect on agents' use of community resources across an urban population. We demonstrate the feasibility of using active learning model exploration techniques on an HPC to characterize large parameter spaces.

3 - Multi-game Modeling for Counter-smuggling

Craig Bakker, Pacific Northwest National Laboratory, Richland, WA, United States, craig.bakker@pnnl.gov, Jennifer B. Webster, Kathleen E. Nowak, Samrat Chatterjee, Casey J. Perkins, Robert T. Brigantic

Trade provides an avenue for terrorists to smuggle illicit materials into a target country. Policymakers need models and decision support tools to inform their responses to this. To that end, we have developed a multi-game model that considers security and economic aspects of counter-smuggling interdiction efforts. Here, we demonstrate the model's capabilities on a representative system of ports, trade routes, and commodities. We find that economic factors play a large role in the interdiction task and provide correspondingly important tools for deterrence.

4 - Optimal Facility Sequencing When Deploying A New Clinical Information System

Nathaniel Horvath, BC Cancer, Vancouver, BC, Canada

This case study presents the problem of replacing the clinical information system in use across cancer centres in British Columbia, Canada. Since centres cannot undergo replacement at the same time, executives must plan a deployment sequence. If two centres are using different information systems, operational overhead increases, as a patient may travel to different facilities in the network for different parts of their treatment. A method is presented to identify such connections between centres. This is combined with a network modelling framework to determine optimal centre pairs for system replacement. These findings informed the organization's current replacement strategy.

5 - Model Predictive Control with Gaussian Process Nonlinear Autoregressive Model and its Application to Energy Storage System Control

Jinkyoo Park, Korea Advanced Institute of Science and Technology, Daejeon, Korea, Republic of, jinkyoo.park@kaist.ac.kr

This paper discusses a data-driven model predictive control (MPC) approach to optimize the operation of an energy storage system (ESS). For every time step, the MPC optimizes a sequence of control actions over a finite horizon using the state transition model and executes only the first action. The performance of the MPC is thus strongly dependent on the predictive accuracy and reliability of the state-transition model (i.e., dynamic model) of a target system. In this paper, we used a Gaussian Process Nonlinear Autoregressive model to predict the distribution on the future state trajectory given the historical state data and use the distribution to optimize the future sequence of control inputs.

6 - Minimizing Radiology Errors Using Discrete System Simulation

Mahdi Nasereddin, Penn State- Berks, Reading, PA, United States, mxn16@psu.edu, Michael Bartolacci

Health care is one of the biggest industries in the United States. To combat increasing costs, the health care industry have emphasized increasing efficiency and reducing errors. One such area that needs improvement is radiology. Missed or delayed diagnostics often results in substantially higher costs later. In medicine, fatigue has been well-documented as a source of medical errors. One of the main sources of fatigue is excessive workload. In this paper we explore using discrete system simulation to predict demand to minimize radiologist fatigue.

7 - On Delivering Fast in Online Luxury Retail

Catarina Pinto, INESC TEC / FEUP, Porto, Portugal, cppinto@fe.up.pt, Pedro Amorim

Despite relying on operational excellence to survive, online grocers often fail by delivering orders that mismatch the ones requested. Few studies have evaluated how customers respond to such events in short-term. By analyzing the changes between subsequent orders, we quantify how customers defect. Our results show a reduction in spending immediately after a failure that increases with the number of failed items. We show the impact of failures depends on the type of failure, customer, and product category. Understanding the magnitude and timing of this reaction leads to personalized inventory management and compensation strategies with important consequences for customer satisfaction.

8 - Fractal Methodology to Explore the Long-Term Memory Behavior to Time Series of Space Data, Using the Hurst Index

Francisco Gerardo Benavides Bravo, Tecnológico Nacional de México, Guadalupe N.L., Mexico

When performing meteorological time series analysis, an important issue is the information underlying these. We use the Rescaled Range (R / S) methodology to explore the behavior of rainfall stations in the San Juan River basin (data provided by the National Water Commission (CONAGUA)) using the fractal exponent. The purpose is to explore the long-range condition, using different Hurst indicators to perform a classification.

■ WA76

S- Metropolitan Ballroom B

Operations/Sustainability I

Contributed Session

Chair: Panagiotis Andrianesis, Boston University, Brookline, MA, 02446, United States

1 - Exploring a Farmer's Production Scheme under Production-dependent Contract Farming

Li-Ming Chen, National Chengchi University, Taipei, Taiwan

Farmers under poverty have the increasing desire of exploiting the new opportunity by farming for those who are socially responsible and willing to source from the poor. This work studies a poor farmer's production decision under production-dependent contract farming from which a farmer prioritizes the supply of goods to a responsible buyer. In return, he benefits from a high premium and guaranteed minimum of the buyers' procurement quantity. We formulate our problem as stylized periodic-review, finite-horizon dynamic programming models and analyze the model structure. We further conduct the numerical study to investigate a farmer's improvement on profitability.

2 - Corporate Social Responsibility and Firms' Resilience to Natural Disasters

Po-Hsuan Hsu, National Tsing Hua University, HSin Chu, Taiwan, pohsuanhsu@mx.nthu.edu.tw, Hsiao-Hui Lee, Long Yi

We propose that corporate social responsibility (CSR) serves as an intangible investment in stakeholder relationships to guard against natural disasters. We develop a stylized model to show that CSR investment, while costly, helps firms recover from natural disasters, thanks to customers' and employees' preferences for CSR. Using factory location data from the toxic release inventory database to specify firms' geographic distribution, we find that firms with higher CSR ratings are much less affected by natural disasters. We then examine the customer and employee mechanisms through which CSR engagement shields firms against natural disasters.

3 - How Does Range Limit Influence the Adoption and Expansion of Electric Vehicles? Evidence from a Commercial Operating Platform

Jingying Ding, Shanghai Jiao Tong University, Shanghai, China

Commercial vehicles such as taxis and buses have significant longer annual ranges than usual household vehicles, which also cause more environmental pressure. Electric vehicles (EVs) could address this problem effectively by reducing the emission of greenhouse gases but there are some difficulties in EVs expansion and development. We study whether range limits or range anxiety have an influence on drivers' adoption of EVs and withdrawal behaviors using a dataset from a commercial operating platform.

4 - Green Fleet Sizing and Routing for Profit Maximization

Isil Koyuncu, University of Alabama, Tuscaloosa, AL, United States, ikoyuncu@crimson.ua.edu, Mesut Yavuz

This talk presents a maximum profit mixed-fleet electric vehicle routing problem with traditional and electric vehicles. A set of customers are willing to pay a green premium to reduce their supply chain carbon footprint. We formulate the emerging rich VRP as a mixed integer linear program, and investigate its exact solution.

5 - Dynamic Pricing in Electricity Distribution Networks; New Business Model

Panagiotis Andrianesis, Boston University, Brookline, MA, 02446, United States, panosa@bu.edu, Michael C. Caramanis

Electricity distribution utilities are confronted today with great challenges resulting from the rapid introduction of Distributed Energy Resources (DERs). DER scheduling is bound to have a profound impact on the adequacy of assets, efficient grid operation, reliability, and security of supply. We claim that the spatiotemporal dynamics of the value of DER interactions with the grid is the key driver of optimal DER scheduling. We present a new business model based on dynamic pricing and optimal DER scheduling, which will bring about fundamental changes in distribution network investment planning, operation, and in current and future power markets.

■ WA77

S- Fremont

Production and Scheduling

Contributed Session

Chair: wenjie Liu, Nanjing University of Aeronautics and Astronautics, Jiangning District, Nanjing, 210006, China

1 - Logic-based Benders Reformulations for Integrated Process Configuration and Production Planning Problems

Karim Perez Martinez, HEC Montreal, Montreal, QC, Canada, karim.perez-martinez@hec.ca, Yossiri Adulyasak, Raf Jans

This research addresses production planning problems where products of different types can be produced simultaneously according to a specific process configuration or pattern. The problem consists of determining the configurations to be used and the production level of each configuration to fulfill the demand at the minimum total cost, which typically includes setup costs, inventory holding or overproduction costs. We propose logic-based Benders reformulations and algorithms to optimally solve this problem in two industrial contexts: the steel industry and the printing industry. The proposed methods outperform the benchmark approaches in the tested problems.

2 - Optimal Sampling Plan of a Multistage Production System with Competing and Propagating Random Shifts

Sinan Obaidat, University of Arkansas, Fayetteville, AR, United States, sfobaida@uark.edu, Haitao Liao

This presentation addresses the problem of finding the optimal sampling policy of a multistage production system subject to competing and propagating random quality shifts. A two-unit serial production system that produces one type of product with a constant production rate is studied. The optimal sampling parameters: sample size, sampling interval, and acceptance threshold are determined by minimizing the long-run cost rate subject to the average time to signal a true alarm, effective production rate, and system's availability constraints.

3 - The Multi-Period Cutting Stock Problem with Diameter Conversion in the Construction Industry

Deniz Altinpulluk, Wayne State University, Detroit, MI, United States, deniz.altinpulluk@gmail.com, Haldun Sural

One-dimensional cutting stock problem has been widely used for reinforcement steel bar in the construction industry. Diameter size of a rebar is determined by structural designer to provide tensile strength to the structure and it can be changed if cross-section area per concrete area stays constant. We study the cutting stock problem that decides diameter size and cutting time and cutting patterns to minimize usage of raw material and holding cost. It differs from classical cutting stock as it is not known how many pieces should be cut until diameter sizes are chosen. We propose a pseudo-polynomial formulation and a genetic algorithm to solve the problem. Computational results are provided.

4 - Scheduling Optimization on Flexible Flow Shop Scheduling Based on a Hybrid Genetic Algorithm with Matrix Coding

wenjie liu, College of Economics and Management, Nanjing University of Aeronautics and Astronautics, Nanjing, China

Flexible flow-shop scheduling problem (FFSP) is a key issue for electronic assembly industry. To solve it, a scheduling optimization model is constructed first. A hybrid genetic algorithm (GA) adopting matrix coding is proposed to solve it by combining a GA with a heuristic rule of First In First Out. Finally, the proposed model and algorithm are used to a case of printer enterprise. Research results show: (1) Order completion time are shortened by more than 20%; (2) Equipment utilization rate rises sharply and exceed 85%. Main contribution of this paper is to yields an effective decision-making tool for FFSP in electronic assembly industry, and to provide an accurate and efficient scheduling solution.

■ WA78

S- Greenwood

Big Data I

Contributed Session

Chair: Davoud Ataee Tarzanagh, University of Florida, Gainesville,, FL, 32611, United States

1 - Auto Recognition with DNA Data for Stages of Osteosarcoma

Yuchen Wang, University of North Texas, Denton, TX, United States, yuchen.wang@unt.edu, Foad Hassanmirzaei, Robert Pavur

Osteosarcoma is the most common bone cancer, yet research on osteosarcoma stages prediction is scarce. The goal of this research is to simplify the diagnostic process using gene testing. For the business disciplines, this research optimizes diagnostic procedures by developing machine learning algorithms to identify cancer stages. The preliminary study uses DNA and clinical data sets from the TARGET database. The five predictive models developed in this study are highly precise. The results show that certain chromosomes are recognized as potential indicators of the cancer stages. These results could improve health management and lower costs.

2 - Big Data Excellence: A Framework for Sustained Performance

Mark Rodgers, Rutgers Business School, Newark, NJ, United States, mrodgers@business.rutgers.edu, Ajai Kapoor, Alok Baveja, Sayan Mukherjee

Businesses rush to implement big data and AI initiatives, often, without clarity on their business problems and the appropriate methodologies to deploy. Anchored in Information theory and relevance of a practitioner's quest for solving a business problem, we present a systematic framework to help managers identify the right question, find the relevant data, choose the appropriate methodology to extract information from data, and find actionable solutions. We also provide a prescriptive, Methodology-choice framework based on the predictability and adaptability of the system. Eleven case studies from various industries show the validity and applicability of the proposed framework.

3 - Leveraging Device Fingerprint Solution for Account Protection Service

Justin Wang, Microsoft, Redmond, WA, United States, justwang@microsoft.com, Jay Pillai

Device fingerprinting is a technique which is used by eCommerce merchants to recognize which devices their traffic is coming from. The technology is wildly used in account protection to prevent fraud. In practice, device fingerprinting solutions need to be implemented close to real time. With internet volume, matching one eCommerce event with the existing thousands of million devices in a few milliseconds is almost impossible. This talk we introduce a hierarchical partition design which can limit the number of matches needed to be evaluated for a given event, discuss how machine learning technology can be applied to improve decision quality and how we select data to train the machine learning models.

4 - Distributed Tensor Principal Component Analysis

Davoud Ataee Tarzanagh, University of Florida, Gainesville, FL, United States, Tarzanagh@ufl.edu, George Michailidis

Tensor PCA is a widely used dimension reduction technique with an extensive range of applications. In this paper, a distributed algorithm is proposed for recovering the principal eigenspaces. We further establish its rate of convergence and show how it relates to the number of nodes employed in the distributed computation, the effective rank of the data tensor under consideration, and the gap in the spectrum of the underlying population covariance tensor. The proposed algorithm is illustrated on low-rank approximation tasks. The numerical results show a substantial computational speed-up vis-a-vis standard tensor PCA algorithms, without compromising learning accuracy.

■ WA79

S- Issaquah A

Energy III

Contributed Session

Chair: Burcu Kose, Rutgers University

1 - Communication-constrained Expansion Planning for Resilient Distribution Systems

Geunyeong Byeon, University of Michigan, Ann Arbor, MI, United States, gbyeon@umich.edu, Pascal Van Hentenryck, Russell Bent, Harsha Nagarajan

Distributed generation and remotely controlled switches have emerged as important technologies to improve the distribution grids' resiliency against extreme weather events. Thus it is important to study how best to place them on the grid to meet resiliency criteria, while capturing their dependencies on communication systems. To address the need, this study introduces the Optimal Resilient Design Problem for Distribution and Communication Systems (ORDPDC) and proposes a Branch and Price algorithm (BP) for the ORDPDC. The ORDPDC and BP were tested on various test cases, and the results demonstrate the impact of network topologies on expansion plans and costs, and computational benefits of the BP.

2 - Multi Objectives Online Scheduling in a Vehicle to Grid System

Zihao Jiao, Beijing Institute of Technology, Beijing, China, Yanzi Zhang

In this paper, we study how to further improve the effectiveness of the vehicle-to-grid (V2G) system as a promising sustainable, flexible operation for the future by integrating energy-storage devices into a charging station with V2G function. Specifically, an integrated multi-objective optimization model is proposed to handle the charging station location, energy-storage device allocation, Electric vehicle charge and discharge scheduling problem in V2G operations. For motivating drivers to sell electricity, we also explore the effect of applying a flexible price framework in V2G operation.

3 - Strategic Microgrid Scheduling with DER to Enhance the Distribution Network Resiliency

Farhad Angizeh, PhD Student, Rutgers, the State University of New Jersey, Piscataway Township, NJ, United States, farhad.angizeh@rutgers.edu, Khashayar Mahani, Mohsen Jafari

In this research work, we aim at developing an operation scheduling model for microgrids with locally-owned distributed energy resources (DER) to enhance the distribution network resiliency. The proposed model, which is developed as a mixed-integer linear programming model, co-optimizes the operation schedules of various DERs, including emergency diesel generator (EDG), PV, combined heat and power (CHP), and energy storage system (ESS), to supply the microgrid demand under both normal and island operation modes. The proposed model enables the microgrid operators to capture flexibilities of DERs to enhance the network resiliency once the upstream grid reliability is jeopardized.

4 - Energy Consumption Based Rendez-vous Problem for Mobile Robots

Nazli Dolu, METU, Ankara, Turkey, ndolu@metu.edu.tr, Mustafa Kemal Tural

We study the problem of finding individual meeting (rendez-vous) points for a group of mobile robots to meet with the tanker robot for recharging by taking the energy consumption of the robots into account. The problem is examined under two different objective functions, one of them is minimizing the total energy consumption and the other is minimizing the total time spent until all the robots are recharged to a predetermined energy level. The energy consumption function of the robots cannot be formulated linearly so that we provide a second order cone programming (SOCP) formulation for the problem.

5 - Money Market for Energy Efficiency

Burcu E. Kose, Rutgers University, New Brunswick, NJ, United States, burcu.kose@rutgers.edu

Promoting energy efficient behavior in commercial and office buildings is a challenge for many building managers. This study explores incentivizing energy efficiency by creating a money market and awarding energy efficient behavior.

■ WA80

S- Issaquah B

Simulation and Optimization I

Contributed Session

Chair: Debdatta Sinha Roy, University of Maryland, College Park, MD, 20742, United States

1 - Lightning Decisions: The United States Marine Corps F-35 Lightning II Maintenance Manning Dilemma

Matthew Hawks, Assistant Professor, US Naval Academy, Annapolis, MD, United States, mhawks@usna.edu

The United States Marine Corps is in the process of integrating the F-35B Lightning II to its fleet of war fighting platforms. Currently, there are questions about the manning of maintenance crews. We focus on optimizing the manning for the Marines attached to the squadrons by simulating maintenance events with current and variable crew allotments. The goal is to optimize maintenance crew numbers while completing required maintenance to maximize mission completion and overall operational readiness of the USMC.

2 - Shicap: A Methodology for Shipyard Facilities Capacity Planning Using DES

Alejandro Garcia del Valle, University of A. Coruna, A. Coruna, Spain, alejandro.garcia.delvalle@udc.es, Rouco Couzo Marcos, Quiroga Pazos Marta, Javier Faulin

The aim of the present work is to establish a methodology, using discrete event simulation, that will be used to determine the required capacity of a shipyard, currently planning to upgrade its facilities. Simulation proves that the existing premises are not sufficient to accommodate for future demand and therefore the required capacity is calculated. Additionally, a sensitivity analysis is conducted to evaluate how variability on critical activities durations would impact on the reliability of the results. Results will be showed for a real shipyard in Spain.

3 - Tree-search Based Bayesian Optimization Algorithms for Stochastic Simulations

Szu Hui Ng, National University of Singapore, Singapore, Singapore, isensh@nus.edu.sg, Songhao Wang

Bayesian optimization is an increasingly popular approach in stochastic simulation optimizations. In this work, we combine this approach with a tree-search partitioning technique. This helps to eliminate the non-trivial optimization of an acquisition function, which is important when we have time constraints on decision making with simulation. We propose a general framework and algorithm with convergence and finite-time regret guarantees. Different from the deterministic cases, here, decision on which node to expand and how to allocate computing budget to the nodes are necessary, and we discuss how these decisions affect the performance.

4 - Simulation Platform to Evaluate the Performance of Sorting and Retrieval Policies in a Logistic Services Container Terminal.

Juan Pablo Cavada, PhD Candidate, Universidad de Chile, Santiago, Chile, jucavada@ing.uchile.cl, Cristian Eduardo Cortes, Pablo Andres Rey

We present a type of depot for containers not commonly studied in the literature, which we call Logistic Services Container Terminal (LSCT).These are inland terminals where full and empty containers are not only stored by clients but also they require service to either the cargo or to the containers themselves. In this paper, we use a stochastic simulation framework to evaluate sorting policies in a LSCT, some of them taken from the literature and other proposed by us, ad-hoc to the features of these terminals and their peculiarities.

5 - Data Driven Optimization and Statistical Modeling to Improve Meter Reading for Utility Companies

Debdatta Sinha Roy, Robert H. Smith School of Business, University of Maryland, College Park, MD, 20742, United States, debsroy@rhsmith.umd.edu, Christof Defryn, Bruce L. Golden, Edward Andrew Wasil

Utility companies collect usage data from meters on a regular basis. Each meter has a signal transmitter that is automatically read by a receiver within a specified distance using radio-frequency identification (RFID) technology. In practice, there is uncertainty while reading meters from the planned routes of the vehicles. The RFID signals are discontinuous, and each meter differs with respect to the specified distance. These factors can lead to missed reads. We use data analytics, optimization, and Bayesian statistics to address the uncertainty. Simulation experiments using real data show that a hierarchical Bayesian model performs the best by designing improved routes for the vehicles.

■ WA81

S- Kirkland

Sustainability I

Contributed Session

Chair: Navid Sabbaghi, Saint Mary's College of California, Martinez, CA, 94553, United States

1 - The 'Degree-of-Health' Concept: Providing the Healthiest Route Through a City

Ben Desmet, Ghent University, Ghent, Belgium, bendsmet.desmet@ugent.be, Nils Van den Steen, Dirk Van den Poel

As urban living is slowly regaining popularity, cities have become ground zero for the struggle between on the one hand a desire for improved mobility and on the other hand increased attention for sustainability. We take a first step to address this. In order to stimulate active transport and inform about the healthiest route, we introduce degree-of-health as a concept. We show this metric is predictable over different timeframes by using sensor data from one of Belgium's largest cities. As proof of concept, the degrees of health of routes are calculated in a small, fictitious case study.

2 - Pricing-newsvendor Problem with Quality-sensitive Demand and Donations

Armagan Ozbilge, PhD Candidate, McMaster University, Hamilton, ON, Canada, ozbilgea@mcmaster.ca, Elkafi Hassini, Mahmut Parlar

Each year, millions of tonnes of foods are wasted causing economic, environmental and social misfortunes. Besides expired items, edible foods are often deliberately disposed of to attract quality sensitive consumers. In this paper, we introduce a quality-dependent newsvendor problem which takes true (effective) quality of the products into account to help food retailers reduce the food spoilage while retaining the profits. We discuss two cases: (1) joint ordering and pricing at the beginning of the period and (2) donation and repricing during the period. We show that donation can reduce waste and increase retailer's profits, with proper incentive mechanism.

3 - Sustainability-oriented Innovation Capabilities in Manufacturing Organisations

Budi Harsanto, University of Liverpool Management School, Liverpool, United Kingdom, harsanto.id@gmail.com
Budi Harsanto, Universitas Padjadjaran, Bandung, Indonesia, harsanto.id@gmail.com, Niraj Kumar, Yuanzhu Zhan, Roula Michaelides

Many companies recently giving increased attention to sustainability-oriented innovation (SOI) in response to a combination of stakeholder pressure and opportunity for growth (Geradts and Bocken, 2019). The aim of this study is to understand the capabilities needed to become a more sustainable innovator. A case study-based approach is employed by using the case of multi-industry manufacturing companies in Indonesia.

4 - Research on Stakeholders Identification and Analysis in Urban Low Carbon Development Project Based on Social Network Analysis Method

Fang Peng, College of Economics and Management, Nanjing University of Aeronautics and Astronautics, Nanjing, China

Urban Low Carbon Development Project(ULCDP) is rapidly advancing on a global scale which is comprehensive involving lots of stakeholders. Their cooperation directly contributes to the success of project. However, these stakeholders have different interest and positions, which leads to hierarchical influence in those projects. This paper proposes a systematic method for evaluating and analyzing the process of ULCDP from the perspective of stakeholders using Social Network Analysis method, and validates the feasibility of this method through case analysis.

5 - Community Contracts

Navid Sabbaghi, Faculty in Business Analytics, Saint Mary's College of California, Moraga, CA, United States

We consider a supply chain setting with a supplier and retailer where the economic benefits of the supplier's production are obtained by one community and where a separate community funds those benefits. We introduce and analyze the effect of contracts that enable the downstream community of consumers to also benefit.

■ WA82

S- Leschi

Carbon Pricing in Electricity Markets

Sponsored: Energy, Natural Res & the Environment/Environment & Sustainability

Sponsored Session

Chair: Mort David Webster, Pennsylvania State University, University Park, PA, 16802, United States

1 - Carbon Pricing on Border Power Flows: The Impact on Investment, Operation and Emission Reduction

Qingyu Xu, Johns Hopkins University, Baltimore, MD, 21218, United States, qxu25@jhu.edu, Jing Peng, Benjamin Field Hobbs

To mitigate carbon leakage, jurisdictions with carbon pricing mechanisms can establish rules governing interactions with other jurisdictions. In the power sector, this usually involves pricing carbon on border flows. Different options for pricing have been proposed or implemented: based on the source, on the marginal emission rate (internal or external), or a fixed or time-varying deemed emission rate. Using JHSMINE, a generation-transmission expansion planning model, we explore the impact of such options on investment, operation, and emission reduction in the western US power system.

2 - Effect of Carbon Pricing on the Generation Investment Decisions of a Strategic Producer

Brayam Valqui Ordonez, M.S., Pennsylvania State University, State College, PA, 16801, United States, bdv3@psu.edu

This paper presents a bi-level optimization model to study the generation investment problem of a strategic producer under different carbon taxes. The upper level, which represents the strategic expansion decisions of a single producer, solves for the optimal investment and the lower level, which represents the ISO's problem, solves for the economic dispatch problems under different scenarios. This model is transformed into an MPEC and solved under different carbon taxes to determine how they impact strategic investment decisions.

3 - Multi-agent Reinforcement Learning for Evaluating Renewable Energy Policies: Impact of Energy Producer's Characteristics

Masaaki Suzuki, Tokyo University of Science, Chiba, Japan, m-suzuki@rs.tus.ac.jp, Mari Ito, Ryuta Takashima

Even as governments combat greenhouse emissions through a range of initiatives, research has not yet clarified how renewable energy policy, energy market structure, and number of energy producers impact social welfare. We model a deregulated market for electricity as a blind single-price call auction and construct a multi-agent system with reinforcement learning that facilitates more realistic market evaluations and observation of equilibrium processes. We then assess the market dynamics that specifically consider the diversity of agents' characteristics.

■ WA83

S- Medina

Power System Resilient Design and Optimization

Sponsored: Energy, Natural Res & the Environment/Electricity

Sponsored Session

Chair: Seyedamirabbas Mousavian, Clarkson University, Potsdam, NY, 13699-5790, United States

1 - Cyber Threats for Urban Distribution Systems: A Case of Manhattan

Yury Dvorkin, New York University, Metrotech Center, Fay Street, New York, NY, 11201, United States, dvorkin@nyu.edu

The roll-out of electric vehicles paves the way to a new cyber-physical attack vector that can be exploited by various state and non-state actors. Using the Borough of Manhattan, New York City, as our case study we demonstrate that malicious actors can collect sufficient information from open-source EV and power grid data sets and design a covert, dynamic cyber attack that is capable of causing instability in the 345 kV transmission network. Using a control- and system-theoretic framework, we analytically demonstrate that such attacks are robust to partial observability of the power system by the attacker and inaccurately approximated power system parameters.

2 - Transmission Expansion Model Considering Flexible Assets Based on AC OPF

Hrvoje Pandzic, University of Zagreb, Unska 3, Zagreb, 10000, Croatia, hrvoje.pandzic@fer.hr

The proposed methodology for transmission expansion planning problem considers investments in flexible assets, i.e. battery energy storage systems and thyristor controlled series compensators, and in traditional assets, i.e. transmission power lines. The proposed model uses a linearized form of AC OPF under Benders decomposition taking the perspective of the system operator.

3 - Robust Stability in Uncertain Power System Optimization Problems

Jianzhe Liu, Argonne National Laboratory, Lemont, IL, United States, jianzhe.liu@anl.gov, Chen Chen, Bo Chen

There is significant uncertainty in power systems where stability and constraint satisfaction are important concerns. Most existing optimization problems that involve uncertain power flows cannot provide stability guarantees. In contrast, our work studies a robust optimization formulation aiming to make both stability and other constraints satisfied. The need to consider uncertainty in the formulation results in a challenging semi-infinite program (SIP). The proposed algorithm reformulates the SIP into a computationally amenable form whose solution provides a feasible point for the SIP. The proposed algorithm is demonstrated using various modified IEEE test cases.

4 - Resilient Network Design of Electricity and Gas Networks

Russell Bent, Los Alamos National Laboratory, Lanl, Los Alamos, NM, 87545, United States, Pascal Van Hentenryck, Seth Blumsack

Recent trends in gas-fired power plant installation has increased the connections between the electric power and natural gas industries. Despite these dependencies commercial, political, operational and technical requirements can sometimes force these industries to plan and operate in isolation. As a result, undesired situations may arise where both systems experience simultaneous high demand that place unexpected stress on the systems (i.e., extreme cold weather events). In this talk, we discuss the technical challenges and present a combined network design planning model to improve the resilience of both system.

■ WA84

S- Ravenna A

Learning and Control of Demand Response (DR) and Distributed Generation (DG)

Sponsored: Energy, Natural Res & the Environment/Energy

Sponsored Session

Chair: Andrew Liu

1 - Learning and Selecting Users for Achieving Reliability in Demand Response: A Multi-armed Approach

Yingying Li, Harvard University, Cambridge, MA, United States, yingyingli@g.harvard.edu, Qinran Hu, Na Li

Major challenges of residential demand response (DR) lie in the uncertainty and randomness of customer behaviors. To learn and select the right customers, we formulate the DR problem as a combinatorial multi-armed bandit (CMAB) problem with a reliability goal. We propose a learning algorithm: CUCBAvg (Combinatorial Upper Confidence Bound-Average), which utilizes both upper confidence bounds and sample averages to balance the tradeoff between exploration (learning) and exploitation (selecting). We study both time-invariant target and time-varying target and proves that CUCB-Avg achieves O(log T) and o(T) regrets respectively. Simulations further show the effectiveness of our algorithms.

2 - Decentralized Demand Response in Electricity Markets

Andrew Lu Liu, Purdue University, School of Industrial Engineering, West Lafayette, IN, 47907, United States, andrewliu@purdue.edu, Zibo Zhao

There has been a rapid growth of distributed energy resources (DERs) in power systems, which cannot be centrally controlled by a system operator. While real-time electricity pricing (RTP) could entice the DERs to act properly, since all DERs would receive the same price signal, naïve response would cause significant price volatility and system instability in real time. To avoid such a “herding” effect, we propose a multiarmed bandit (MAB) game framework in which each consumer employs a policy to minimize cumulative regret. Numerical results show fast convergence to a steady-state of the MAB game with much reduced price volatility and higher social welfare than the naïve-response case.

3 - Optimal Electricity Distribution Pricing under Risk and High Photovoltaics Penetration

Xinyue Song, Johns Hopkins University, Baltimore, MD, United States, xsong11@jhu.edu, Maxim Bichuch, Benjamin Hobbs, Yijiao Wang

We consider a reverse Stackelberg game in the electricity market between a centralized regulator and rational consumers with stochastic demand. A typical consumer is allowed to generate PV electricity to offset his power demand (and sell the excess back), and optimizes this decision to maximize his total utility from the income or bills. He affects the bulk market price, and hence all consumers, by contributing to the overall market demand. The regulator sets up distribution fees so as to recover grid maintenance costs and encourage PV penetration. We study the Nash equilibrium of generation decisions, and present data calibrated results on the coupled decision making of the consumers and regulator.

4 - Valuation of Flexible Energy Resources in a Nonbinding Commitment Transactive Energy Market

Somayeh Moazeni, Stevens Institute of Technology, Babbio Center, Hoboken, NJ, 07030, United States, smoazeni@stevens.edu, Boris Defourny

Current distribution systems cannot support simultaneous and identical actions of a large number of distributed flexible energy resources reacting to an identical signal. This talk presents a transactive energy market framework when their access to transactions is restricted. A nonlinear pricing structure incentivizes small transactions spread out among arrivals of operation opportunities. A self-exciting point process expresses operation permissions. The problem of optimal operations in this market to maximize the cumulated revenue is modeled as a piecewise deterministic Markov decision process. Various properties of the optimal value and sensitivity to market parameters are studied.

■ WA85

S- Ravenna B

Data Mining V

Contributed Session

Chair: Saurabh Kumar, Indian Institute of Management Indore

1 - Extended Similarity Measures to Predict High Cost Patients in USA Medicare Advantage Plans

Michael Mannino, University of Colorado Denver, Denver, CO, United States, Michael.Mannino@ucdenver.edu, Joel Fredrickson

This research proposes similarity measures to predict high cost patients in USA Medicare Advantage plans. Classification of high cost patients helps determine cost reimbursement, target effort for care management, and identify patients with most serious conditions. We design and test nearest neighbor algorithms employing similarity measures derived from patient attributes and abstracted claims histories. The novel similarity measures use claims cost, partial matching of diagnosis codes, and diagnosis severity for each encounter in a claims history. We evaluate this new method against the CMS-HCC model, commonly used to perform large population risk prediction and cost adjustment.

2 - A Novel Metric for Search Engine Evaluation

Aarushi Jain, PhD Student, Indian Institute of Management-Indore, Indore, India, f17aarushij@iimidr.ac.in, Rajhans Mishra

Several researchers have compared various search engines and identified how one search engine is superior to others. In this work, a performance evaluation metric is prepared for three search engines i.e., Google, Yahoo, and Bing. Using the performance evaluation parameters Content Similarity, Domain Similarity, Structural Similarity, and Sequential Similarity, we found out which search engine provides better information on the basis of their similarity of content, their sequence of information, the positioning of websites on the internet, and the positioning of the anchor texts within a website.

3 - Read the News, Not the Books: Predicting Firms Financial Health

Sophie Zhai, Iowa State University, Ames, IA, United States, Drew Zhang

In this paper, we show that mining firm-related events in public news can effectively predict various firm financial ratios. By exploiting state-of-the-art neural architectures including pseudo-event embeddings, Long Short-Term Memory Networks, and attention mechanisms, our news-powered deep learning models are shown to outperform standard econometric models operating on precise historical accounting data. We also observe forecasting quality improvement in multi-task learning settings. Our forecasting models (and byproducts such as attention maps and firm embeddings) benefit various stakeholders with not only quality predictions but also explainable insights.

4 - Multivariate Adaptive Regression Splines Knot Selection and Global Optimization

Xinglong Ju, The University of Texas at Arlington, Arlington, TX, United States, xinglong.ju@mavs.uta.edu, Victoria C.P. Chen, Jay Michael Rosenberger, Feng Liu

Multivariate adaptive regression splines is a popular statistical modeling method. In the MARS model building process, knot positioning is a critical aspect that potentially affects the accuracy of the final MARS model. By exploring the lack-of-fit (LOF) function within MARS, we find that local optima from previous model building iteration are very close to those of the current iteration. In our approach, this prior LOF information is used to warm start a local optimization algorithm for knot positioning. A novel method is proposed to do global optimization analytically on two-way interaction truncated linear MARS by using mixed integer quadratic programming.

5 - Privacy Preserving Recommender Systems in Mobile Context Using Privacy Dashboard

Saurabh Kumar, Indian Institute of Management Indore, Indore, India, saurabhkumar@iimidr.ac.in, Mukul Gupta

The paper proposes a Privacy Preserving Recommendation Systems (PPRS) which focuses on providing the customised recommendations to the smartphone users without hampering the privacy of the users with the aid of privacy dashboard techniques. PPRS investigates how the location data of users is processed for generating personalised contents and advertisements for mobile devices. But the users will also have access to the information which they wish to share with the service providers. Together with the data practices and opt-out option, a simplified Privacy-Dashboard is proposed which have the option of controlling the access of information to any other third party.

■ WA86

S- Ravenna C

Modeling and Control of Smart Manufacturing Systems I

Emerging Topic: Advanced Manufacturing

Chair: Feng Ju, Arizona State University, Tempe, AZ, 85281, United States

1 - The Joint Cognitive Work of Production Scheduling

Peter O. Denno, Researcher, NIST, Gaithersburg, MD, United States, peter.denno@nist.gov

Humans provide at least two unequaled abilities: a circumspect ability to interpret situations, and a generative ability to hypothesize about causality in the system. We use these abilities to step in when system behavior goes awry and to devise plans for a better system. Can we build systems around these abilities? I will take up this question in the context of production scheduling at small and medium-sized manufacturers, and discuss a methodology and tools to enable SMEs to pursue increasingly effective solutions to production scheduling problems.

2 - Real-time Control for Multi-stage Serial Production Line with Residence Time Constraints

Feifan Wang, Arizona State University, Tempe, AZ, 85281, United States, feifan.wang@asu.edu, Feng Ju

Potential quality problem may occur, and production cost may increase, if residence time of intermediate products is left uncontrolled. The real-time production control that guarantees a high production rate and small scrap rate is beneficial in practice. However, such a production control is difficult to derive due to the large state space of this problem. In this study, we propose a novel aggregation-based method for production control, and simulation study suggests that the proposed method can improve system performance with small computational cost.

3 - Throughput Improvement of Serial Production Lines via Downtime Reduction

Mengyi Zhang, Politecnico Di Milano, DIP. Meccanica, Milano, Italy, Andrea Matta

Throughput is one of the key performance indicators for manufacturing systems, and its improvement remains an interesting topic in both industrial and academic field. One way to achieve improvement is reducing downtime of unreliable machines. Under integrated simulation optimization framework, this paper develops Mixed Integer Linear Programming (MILP) models to improve system throughput by reducing downtime in the case of multistage serial lines. A variant of the proposed MILP can be used for the downtime bottleneck detection. Comparison with state-of-the-art approaches shows the effectiveness of the approach.

4 - Performance Evaluation of Queueing Networks with Nonstationary Demand, Part Priorities and Finite Buffers

Ronald G. Askin, Arizona State University, School of Computing, Informatics Engineering, Ira A. Fulton Schools of Engineering, Tempe, AZ, 85287-8809, United States, Ron.Askin@asu.edu, Girish Jampani Hanumantha

Manufacturing systems can be modeled as networks of queues, however models typically assume stationary arrival and processing rates. In this talk we present a computationally efficient approximation method for performance evaluation of queueing networks with known nonstationary arrival rates, controllable processing times (speeds and number of machines), part type priorities at workstations and finite staging buffers at workstations. Empirical results are shown for accuracy and computational time.

Wednesday, 9:40AM - 10:30AM

■ Keynote

CC- Room 6C

Keynote: People, Machines, and Intelligence

Emerging Topic: Keynote

1 - People, Machines, and Intelligence

Eric Horvitz, horvitz@microsoft.com, Redmond, WA, United States

Advances in capabilities and applications of machine learning have brought to the fore multiple challenges and opportunities with human-AI collaboration. I will present research on principles and mechanisms for harnessing the complementary skills of people and machines. Studies in this area show the promise of aiming machine learning, decision making, and optimization at the challenge of weaving together human and machine intellect. I will describe efforts on guiding the display of information, controlling a mix of human and machine initiatives, fusing human and machine contributions, and shaping the construction of predictive models based on human capabilities. I will introduce key ideas and solutions in the context of efforts in transportation, aerospace, healthcare, and productivity applications.

■ Keynote

CC- Room 6B

Keynote: Marketplace Modeling: Managing Scale and Accuracy

Emerging Topic: Keynote

1 - Marketplace Modeling: Managing Scale and Accuracy

Nicolas Stier-Moses, Facebook, 1 Hacker Way, Menlo Park, CA, 94025, United States

Marketplace modeling is a research area that has had widespread real-world impact within the OR/MS community. Focusing on scale and accuracy, we will discuss some techniques we have been using to enable better decision-making for concrete applications, such as matching jobs and applicants, blood donation recommendations, friend suggestions, rendering feeds, and online advertising. These techniques include using competitive equilibria to compute allocations, finding compact representations of marketplaces, and using Bayesian optimization coupled with simulation to improve model accuracy.

Wednesday, 11:00AM - 12:30PM

■ WB01

CC- Room 201

Data Science Applications in Healthcare Sector

Sponsored: Data Mining

Sponsored Session

Chair: Tannaz Khaleghi

1 - Improving Surgical Service Operations Using Predictive Analytics

Tannaz Khaleghi, Wayne State University, Detroit, MI, 48201, United States, fj6710@wayne.edu

Surgery, intrinsically inherited by a set of vital activities which can be characterized by single or multiple codes, so-called Current Procedure Terminologies (CPT), that are maintained by the American Medical Association. CPT code identifies to insurance companies what type of care was provided. The surgery scheduler also forms the daily schedule based on case CPTs. In this study, we share our experience of an ongoing research to develop predictive models by text mining and machine learning tools to clean the unstructured surgery text, extract text features and predict the CPTs. We further highly value CPT codes as a key factor in estimating surgery duration more accurately.

2 - Prescriptive Analytics for Dynamic Task Assignment and Coordination of Inpatient Operations in Hospitals

Najibesadat Sadatijafarkalaei, Wayne State University, Detroit, MI, 48201, United States

Most hospital systems in the U.S. have employed some form of an Electronic Health Record (EHR) system in recent years to improve information flow and health outcomes. The information available in EHR systems can play a significant role in providing better coordination between different departments/services in the hospital through optimized task/resource allocation. We present a dynamic real-time coordination framework for resource and task assignment to establish automated coordination of health operations across emergency department (ED) and inpatient unit (IU) network. This research is in collaboration with Henry Ford Health System of SE-Michigan.

3 - Integrating Process Knowledge into Change Point Detection in Healthcare Systems

Suleyman Yildirim, Wayne State University, Detroit, MI, 48201, United States, suleymanyildirim@wayne.edu, Alper E. Murat, Murat Yildirim

Increasing complexity of modern systems require dynamic simulation models that update based on real-time data. The primary goal of this research is to propose a simulation framework that discovers and adapts to dynamic process knowledge of complex healthcare systems. We develop machine learning based discovery and calibration methods that integrate time series based Artificial Neural Network with Change Point Detection algorithms. The proposed framework achieves significant improvements in prediction accuracy, and provides an extensive basis for automated discovery of process knowledge in a general class of complex systems.

■ WB02

CC- Room 202

Models and Algorithms for Prescriptive Analytics

Sponsored: Data Mining

Sponsored Session

Chair: Adam Elmachtoub

1 - Bootstrap-Based Exploration for Continuous Space Reinforcement Learning

Mohamad Kazem Shirani Faradonbeh, University of Florida, Gainesville, FL, United States, mfaradonbeh@ufl.edu, Ambuj Tewari, George Michailidis

In decision making problems for continuous state and action spaces, linear dynamical models subject to quadratic cost functions capture a large number of applications. Recent approaches in reinforcement learning employ randomized policies to address the trade-off between exploration and exploitation. One such policy prescribes to do the exploration through bootstrapping observed states and actions. We show that bootstrap-based policies achieve a square root scaling of regret with respect to time, and also specify the accuracy of learning the model. Further, we study robustness of the proposed adaptive policy to unknown and sudden changes in the dynamical model.

2 - Interior Point Methods with Adversarial Networks

Rafid Mahmood, University of Toronto, 3831 Janice Drive, Toronto, ON, L5M 7Y6, Canada, rafid.mahmood@mail.utoronto.ca, Aaron Babier, Adam Diamant, Timothy Chan

We consider a data-driven framework for learning to generate decisions for continuous optimization problems containing constraints that: (i) are not a priori specified, and (ii) vary with an instance-specific input. Our approach uses two machine learning models. The first is a feasibility classifier; we use it as a barrier function in an interior point method (IPM) to train the second model to generate decisions. In this work, we first develop optimality theory for IPMs when given a barrier that relaxes the feasible set, which we extend to probabilistic guarantees for learning. Finally, we implement our methods to predict personalized radiation therapy treatment plans in head-and-neck cancer.

3 - A Hierarchical Framework for Fair Data-driven Decisions

Mahbod Olfat, PhD Student, University of California-Berkeley, Berkeley, CA, 94702, United States, molfat@berkeley.edu, Anil Aswani

A trend in recent approaches to algorithmic fairness has been to make modifications to the optimization through which training is done itself, as opposed to modifying the data inputs or predictions output. We argue that all major notions are actually forms of robust conditional independence, and design a hierarchical optimization framework that can approximate such independence constraints using existing optimization tools. We also provide mechanisms for efficiently solving lower orders of the hierarchy, and present empirical results on a number of datasets.

4 - Safety Evaluation of Black-box Prediction Models via Rare-event Simulation

Zhiyuan Huang, University of Michigan, Ann Arbor, MI, United States, zhyhuang@umich.edu, Ding Zhao, Henry Lam

We study the design of good importance samplers to simulate the probability that a black-box predictor, built for instance from machine learning tools such as neural networks and random forests, outputs an exceedingly high prediction value. This problem is motivated from robustness and safety estimations that arise in recent applications of autonomous vehicles and other physical systems. Our approach utilizes mixed integer programming and a "cutting plane" approach to sequentially locate dominant points that guide the tilting of distributions in the importance samplers.

■ WB03

CC- Room 203

Innovations in Healthcare

Sponsored: Manufacturing & Service Oper. Mgmt/Healthcare Operations

Sponsored Session

Chair: Mili Mehrotra, University of Illinois at Urbana Champaign, Champaign, IL, 55455, United States

1 - Socially Optimal Contracting Between a Regional Blood Bank and Hospitals

Tharanga Kumudini Rajapakshe, University of Florida, Gainesville, FL, 32608, United States

Motivated by the operational challenges faced by a Regional Blood Bank (RBB) in distributing the blood among the hospitals in its service area, we study socially optimal contracting decisions of an RBB serving multiple hospitals. In the face of supply uncertainty, hospitals tend to over-order to compensate for a potential supply shortfall. We model the blood bank as a social planner with the objective of minimizing the total cost of shortages and outdates throughout the supply chain. We show that if the blood bank offers a suitable per unit subsidy for every unit of shortage experienced by a hospital, then hospitals would be induced to report demand to the blood bank without inflation.

2 - Analysis of Hospital-physician Gainsharing Contracts

Mili Mehrotra, University of Illinois at Urbana Champaign, Champaign, IL, 55455, United States

Under Episode-based Payment Models (EPMs), CMS allows a hospital to share gains/losses from reconciliation process and/or from its internal operations to incentivize physicians to select a treatment option that will improve quality and reduce cost. In this paper, we consider a class of linear gainsharing functions and study the impact of the stop-loss and stop-gain provisions imposed by CMS, the maximum savings potential, and the risk preferences of the hospital and physicians on gainsharing and the choice of treatment options.

3 - Designing Safe and Scalable Precision Medicine Supply Chain: Evaluating the Implementation of Guidelines

Jingwen Yang, PhD Student, Carlson School of Management, University of Minnesota, Minneapolis, MN, United States, yang5435@umn.edu, Anant Mishra, Kingshuk Sinha

Motivated by the challenges of integrating precision medicine based care into routine clinical practices, we empirically examine the effect of CPIC guidelines on building a safe and scalable precision medicine supply chain. The analysis is based on a sample of 26 FDA approved psychiatric precision medicine drugs. The results indicate that CPIC guidelines are associated with increased safety and scalability of precision medicine supply chain for psychiatric care delivery.

4 - Models for understanding Benefits-Value-Advisor (BVA) Program

Jingyao Huang, University of Texas at Austin, Austin, T X. 7870, Austin, TX, 78705, United States, jingyao.huang@mccombs.utexas.edu, Diwakar Gupta

We use a game-theoretic model to investigate providers' price and quality decisions under the Benefits-Value-Advisor (BVA) program, which is aimed at reducing the cost to self-insured employers of shoppable medical services. Under BVA, patients can call a consultant to get cost and quality information about in-network providers. BVA adds value by lowering members' search costs and by lowering insurer's cost via price transparency and gentle nudging. We are interested in two questions: (1) How will providers set price and quality levels in response to the BVA program? (2) What combinations of incentives, penalties, and payment regimes should the insurer use to lower cost and improve quality?

■ WB04

CC- Room 204

Social Media Analytics: Contemporary Topics and Techniques

Sponsored: Data Mining

Sponsored Session

Chair: Son Hyunsang

1 - Brand Personality Congruity on Social Media: The Impact of Brand-Consumer Personality Distance on Electronic Word-of-Mouth (eWOM)

Arnold Dongwoo Chung, The University of Texas at Austin, Austin, TX, United States, adwc86@utexas.edu, Yoonhi Sung, Hyunsang Son, Joshua Ryoo

This study explored messages both from brands and consumers on Facebook based on Aaker's (1997) brand personality dimensions and to look into the impact of brand-consumer personality congruity on electronic word-of-mouth. All of the existing brand messages were collected from the 2015 Interbrand 100 brands' Facebook pages. For the consumer-generated messages, messages of the top 25 comments of each brand message were collected. The findings showed the extent to which brand messages were congruent with consumer comments for each brand. In addition, the results suggested that congruity between brand messages and consumer comments was positively correlated with the total number of comments.

2 - What Does Matter Most in Business Communication? Who, What, or How?

Kwangjin (KJ) Lee

Please check the mobile app for this abstract.

3 - Is Picture Worth a Thousand Words?

Young Eun Park, Colorado State University, Fort Collins, CO, United States, Young.Park@colostate.edu, Hyunsang Son

We utilized newly developed machine learning and deep learning techniques to analyze the textual data and to estimate how different features of textual data predict users' reactions toward the articles and comments.Utilizing Latent Dirichlet Allocation (Blei, Ng, and Jordan 2003). In future research, we will evaluate the different effects of each topic and other features such as whether a certain comment was chosen by an editor or not, the comment's level of trustedness, the number of recommendations, and the sentiment of the comments (positive vs. negative) in order to predict readers' article and comment sharing behavior using Variational Autoencoders (VAE) (Yang et al., 2017).

4 - What Did People Seek and Share in Natural Disasters?

Jisoo Ahn

Please check the mobile app for this abstract.

■ WB05

CC- Room 205

Data Analysis in Finance

Sponsored: Data Mining

Sponsored Session

Chair: Xiaodi Zhu

1 - Energy Exchange Traded Funds Jump Effects with Hawkes Processes

Steve Yang, Stevens Institute of Technology, Babbio Center, Hoboken, NJ, 07030, United States, steve.yang@stevens.edu

In this study, we focus on the Exchange Traded Funds (ETFs) in the energy sector and conduct a high frequency data modeling on their return jumps based on Hawkes Processes. It is known in the current literature that energy ETFs returns are highly correlated with equity market performance in general. We construct two multivariate Hawkes processes to examine the self and cross excitation effects of future indices and three different types of ETFs. We show that both the oil and S&P 500 future indices lead the ETFs return jumps. Moreover, the Master Limited Partnership (MLP) ETFs have least influence from the future indices compared with other energy ETFs.

2 - The Primacy of Numbers in Financial and Accounting Disclosures: Implications for Textual Analysis Research

Federico Siano, Boston University - Questrom School of Business, Boston, MA, United States, fsiano@bu.edu

Numbers are central to financial and accounting disclosures, yet current textual analysis research dissociates words and numbers, or ignore numbers altogether, within disclosures. We hypothesize and show that the prevalence of numbers within a corporate disclosure is highly correlated with the readability of the disclosure. More importantly, we show that prior findings on the links between disclosure readability and various economic outcomes are explained by the prevalence of numbers within the disclosures. We discuss implications for past and future research that attempts to analyze the determinants, attributes and outcomes of financial and accounting disclosures.

3 - Trader Behavior Detection Using Reinforcement Learning

Xiaodi Zhu, Assistant Professor, New Jersey City University, Jersey City, NJ, 07030, United States, xzhu@njcu.edu, Xugong Li

Stock traders apply different strategies to make trading decisions. However, some traders try to make profit by manipulating the price of securities, such as spoofing and pinging trading. Detecting improper trading behaviors is crucial to brokers and regulators. This paper considers trading behavior as a Markov decision process and applies reinforcement learning framework to analyze different behaviors. We further distinguish normal trading and improper trading behaviors using clustering algorithm. This model tends to contribute to automatic trading behavior detection system that benefits market regulators and broker companies.

■ WB06

CC- Room 209

Joint Session DM/Practice Curated: Data Analytics and Machine Learning in Smart Supply Chain

Sponsored: Data Mining

Sponsored Session

Chair: Jerry Kam

Chair: Shouyi Wang

1 - A General Dual Sourcing Inventory Model: Trading Off Lead Time and Cost Differences

Zhe Liu, Imperial College London, 3022 Broadway, London, 10027, United Kingdom, Awi Federgruen, Lijian Lu

We study a single product, periodic review inventory system with two suppliers and salvage options. A regular supplier has a longer lead time but is cheaper than an expedited supplier. Salvage options allow for bilateral inventory adjustments. All inventory adjustments involve a fixed cost component in addition to variable costs or revenues and may be capacitated. We show that the optimal order sizes and/or salvage quantity follow a relatively simple structure. This applies when the lead times of the two suppliers differ by a single period. However, our structural results suggest effective heuristics for general lead times and demonstrate the significant benefits of dual sourcing.

2 - Learning-based Approach for Combined Set Covering and TSP

Yuwen Yang, University of Pittsburgh, Pittsburgh, PA, 15213, United States, yuy49@pitt.edu, Bo Zeng, Jayant Rajgopal

Last-mile vaccine delivery can be complex in regions with geographically dispersed and nomadic populations, and outreach is utilized to raise immunization rates. A set of population centers is chosen, and over a suitable time horizon, clinicians are sent from a depot to set up mobile clinics to vaccinate surrounding areas. The optimization model for this results in a combination of a Set Covering problem and a TSP. Repetitively solving this via MIP could be computationally expensive, and we explore Machine Learning as a way to effectively deal with the problem. The proposed framework is to establish supervised models that generate solutions with minimum total cost.

3 - Dynamic Car Planning

Huichiao Jen, CSX, 500 Water St, Jacksonville, FL, 32202, United States, Jerry Kam

Rail car planning is a challenge problem for railroad. Railroad would like to know how many cars will arrive in each station in order to have better resource planning especially at the interchange stations. Rail cars come from foreign railroad to CSX network with very short notification before they enter CSX network. This study uses offline event data that receive from foreign railroad to build a machine model which estimate travel time between foreign (intermediate) location and CSX interchange location once the rail cars depart from foreign original locations and toward to CSX interchange location.

4 - Forecasting Statistical Distribution of Retail Demand by Pattern Mining of Historical Prediction Residuals and Modeling Error

Kin Ming Kam, JD.com, BDA, Beijing, 100176, China, jerrykam@hotmail.com

This presentation is about a data mining research on distribution forecasting which supports inventory management in a retail giant in China. The inventory replenishment and reallocation do not only need the most probable demand but also the statistical distribution of the demand. In the tasks of inventory optimization, we want to have enough safe stocks to avoid out-of-stock while keeping the inventory level at the minimum. So, instead of the most probable value, we in fact want a percentile, e.g. 95th percentile, of the prediction based on the uncertainty of the prediction result. To forecast the future distribution of the forecast, we leverage the historical residual and training error.

■ WB07

CC- Room 210

Contract Theory, Control, and Applications

Sponsored: Data Mining

Sponsored Session

Chair: Dylan Possamai

1 - A General Theory of Non-Markovian Consistent Planning

Camilo Hernández, Columbia University, New York, NY, United States, camilo.hernandez@columbia.edu

We develop a theory for continuous-time non-Markovian stochastic control problems which are time-inconsistent (P). For these problems the classical dynamic programming principle (DPP) do not hold. We a sophisticated agent seeking for consistent plans. We introduce a new definition of equilibrium that allows us to prove an extended DPP. Consequently, we pose a system of BSDEs (H) and obtain a verification result. Moreover, (H) is also necessary for (P). This is, given an equilibrium it must necessarily maximise the Hamiltonian of (H) and the associated value function induces a solution to (H). We also provide a well-posedness result in the case of uncontrolled volatility.

2 - Contract Theory in a VUCA World

Nicolás Hernández, University of Michigan, Ann Arbor, MI, United States, nihernan@umich.edu, Thibaut Mastrolia

In this paper we investigate a Principal-Agent problem with moral hazard under Knightian uncertainty. We extend the seminal framework of Holmström and Milgrom (1987) by combining a Stackelberg equilibrium with a worst-case approach. We study a general model in the spirit of Cvitani , Possamaï, and Touzi (2017). We show that optimal contracts depend on the output and its quadratic variation by extending Mastrolia and Possamaï (2018) and Sung (2018). We compute the optimal effort of the Agent through the solution to a second order BSDE and we show that the value of the problem of the Principal is the viscosity solution of a Hamilton-Jacobi-Bellman-Isaacs equation, by using stochastic Perron's method.

3 - Rational Inattention and Dynamic Discrete Choice

Hao Xing, Boston University, Boston, MA, United States, haoxing@bu.edu, Jianjun Miao

We adopt the posterior-based approach to study dynamic discrete choice problems with rational inattention. We show that the optimal solution for the Shannon entropy case is characterized by a system of equations that resembles the dynamic logit rule. We propose an efficient algorithm to solve this system and apply our model to explain phenomena such as status quo bias, confirmation bias, and belief polarization. A key condition for our approach to work in dynamic models is the convexity of the difference between the discounted (generalized) entropy of the prior beliefs about the future states and the entropy of the current posterior.

4 - Demand-response Management for Mean-field Electricity Consumers

Dylan Possamaï, Assistant Professor, Columbia University, New York, NY, United States, dp2917@columbia.edu

We study the problem of demand response contracts in electricity markets, considering a mean-field of consumers. We formulate the problem as a Principal-Agent problem with moral hazard in which the Principal is an electricity producer who observes continuously the consumption of a continuum of risk-averse consumers, and designs contracts in order to reduce her production costs. We prove that the producer can benefit from indexing contracts on the consumption of one Agent and aggregate consumption statistics from the distribution of the entire population of consumers. In the case of linear energy valuation, we provide closed-form solutions.

■ WB08

CC- Room 211

Artificial Intelligence I

Contributed Session

Chair: Shahriar Jahan Hossain, Northwestern State University, Natchitoches, LA, 71457-5947, United States

1 - A Closed-loop Stencil Printing Control System Using a Hybrid Online Learning and Heuristics Approach

Hongya Lu, Binghamton University, Binghamton, NY, United States, hlu26@binghamton.edu, Haifeng Wang, Sang Won Yoon, Daehan Won

This research aims to develop a dynamic optimization model performing real-time control of a stencil printing process (SPP) by maintaining optimal printer parameter settings. To improve the SPP system performance in a dynamic environment, this research proposes an online optimization model by using online learning to predict real-time SPP status and the Evolutionary Search (ES) to determine optimal settings. From the model selection from the online based learning, a multi-layer Online Sequential Extreme Learning Machine shows high accuracy. From the real implicational results, the proposed SPP system shows outstanding results in Cpk, promising the potential of online learning in SMT control.

2 - Predicting Combat Outcomes in Real-time Strategy Games Using Deep Learning

In Sung Baek, Korea University, Seoul, Korea, Republic of, insung.baek01@gmail.com, Seoung Bum Kim

Predicting intermediate combat results in real-time strategy games such as StarCraft II is one of the most important issues because the combination of various battle outcomes eventually determines the final winner of the game. However, in StarCraft II, it is difficult to predict battle outcomes because of numerous factors including the diversity of units, the diversity of unit combinations, and unit upgrades. In this study, we propose a game result prediction model based on deep learning approaches.

3 - Breaking Through Barriers to Deep Learning Adoption in Customer Behavior Modeling

Mustafa Murat Arat, University of Tennessee, Knoxville, Knoxville, TN, United States, marat@vols.utk.edu, Michel Ballings, George Miller Moore

The purpose of this study is to subject to scrutiny commonly held beliefs that are precluding the adoption of deep learning in customer behavior modeling. We provide the following collection of conjectures: deep learning methods (i) will fit spurious relationships, (ii) are better at predicting than standard linear models, (iii) are black box and cannot be used for explaining, (iv) they cannot do joint estimation or fit random effects, and (v) are too expensive and difficult to make them work. We provide mathematical, visual, and textual explanations to refute these beliefs and deliver a proof of concept in the form of a case study on customer lifetime value modeling using deep learning.

4 - Using Artificial Intelligence and Natural Language Processing to Predict Alzheimer's Disease

Maryam Zokaeinikoo, Pennsylvania State University, State College, PA, United States, mzz30@psu.edu

Automatic diagnosis of Alzheimer's disease and dementia can help with early detection of these diseases. We propose different neural network models based on Long Short Term Memory networks (LSTM) to detect the onset of Alzheimer's early in the course of the disease using textual data from both healthy subjects and patients. These models include LSTM networks, bidirectional LSTM (BLSTM), bidirectional LSTM with attention layer (Attention-BLSTM), Multi-head attention, Adversarial and bidirectional LSTM with conditional random fields layer (CRF-BLSTM).

5 - Surface Roughness Prediction Modelling for 3d Printed Parts

Md Shahriar J. Hossain, Assistant Professor, Northwestern State University, Natchitoches, LA, United States, msjhossain1@gmail.com, Jafar Al-Sharab, Curtis Desselles

Surface roughness (SR) is viewed as a crucial quality aspect of 3D printed models in fused deposition modeling (FDM) technology. In FDM, SR depends on several system parameters including build angle, layer thickness, temperature, % infill and feed rate. An efficient prediction model is required for presetting the parameters that can result a desired SR. In this research, a data driven artificial intelligence-based prediction model is proposed. Taguchi design of experiment is followed in data collection. These data are further used for training ANN, ANFIS and multiple regression models. The best model is selected based on minimum mean square error generated in the k-fold cross validation.

■ WB09

CC- Room 212

Relational Analytics

Sponsored: Artificial Intelligence

Sponsored Session

Chair: Zhiya Zuo, University of Iowa, Iowa City, IA, 52240, United States

1 - Personalize Weight-loss Goals on Online Healthcare Platforms: A Multi-arm Bandit Approach with Dynamic Discrete Choice Scheme

Tongxin Zhou, University of Washington, Seattle, WA, 98105, United States, Yingfei Wang, Lu Yan, Yong Tan

Many online healthcare platforms provide patients with healthcare interventions. However, implementing healthcare interventions is still challenging in practice. First, healthcare intervention needs to be assessed for each individual as healthcare is highly personal. Second, adequate information is required in order to deliver effective interventions, which brings challenge to newly-started platforms. To address these challenges, in this study, we propose a Multi-armed bandit (MAB) approach for offering healthcare interventions. In evaluating the effectiveness of the MAB approach, we further establish a structural model to depict individuals' healthcare decision making.

2 - understanding and Predicting Individuals' Future Success – A Social Capital Perspective

Zhiya Zuo, City University of Hong Kong, Kowloon, 52240, Hong Kong, zhiyazuo@gmail.com, Kang Zhao

In this study, we investigate individuals career success trajectories from a social capital perspective. For early- and mid-career professionals: (i) experience with high-standing colleagues is a consistent predictor for future attainments; (ii) being a broker who connects various communities, though no immediate effects, is a signal of long term success. For senior professionals, building new ties with high-standing colleagues is a minute yet significant predictor for future impact. Findings provide implications for hiring organizations and individuals strategically planning career paths.

3 - Online Interactions and the Spatial Diffusion of Crowdfunding

Keongtae Kim, Chinese University of Hong Kong, Shatin, Hong Kong, keongkim@cuhk.edu.hk, Jooyoung Park, Sunil Mithas

This study documents the role of online social interactions in the diffusion of crowdfunding. Using the data on the creation of crowdfunding projects from 2009 to 2013 and Facebook Social Connectedness Index Data, we find that the number of crowdfunding projects in an area is positively associated with the number of prior crowdfunding projects from areas that are online socially connected. The association is stronger when considering large, successful projects. The peer effect from the socially connected areas becomes larger as the crowdfunding adoption from geographically proximate areas increases. Last, the influence of virtually connected areas is stronger for areas that are well off.

4 - Against Voting? The Crowd Classification Problem

Joshua Becker, Kellogg School of Management, Evanston, IL, United States, joshua.becker@kellogg.northwestern.edu, Douglas Guilbeault, Edward Smith

Decades of research has shown that information exchange improves group judgments. However, we show both theoretically and experimentally that this effect is limited to numeric judgments. In discrete choice estimates, also known as classification tasks—e.g. yes/no decisions, or selecting between two options—social influence simply amplifies the majority, regardless of accuracy. Thus inaccurate groups become less accurate but show greater consensus. Surprisingly, even when people exchange numeric estimates before voting, the vote becomes less accurate even as the average estimate becomes more accurate. These results point to the need for a contingency theory of collective intelligence.

■ WB10

CC- Room 213

Information Operations in Social Networks

Sponsored: Social Media Analytics

Sponsored Session

Chair: Tauhid Zaman, MIT, Boston, MA, 02114, United States

1 - Influence Maximization with Stubborn Agents under Time-varying Dynamics

David Scott Hunter, Massachusetts Institute of Technology, Cambridge, MA, 02139, United States

We consider the problem of optimizing the placement of stubborn agents in a social network in order to maximally influence the population. To model the opinion of the agent's in the network, we propose a new opinion dynamics model that is motivated by research in psychology. Under this model, we consider maximizing the mean opinion and also maximizing the number of individuals whose opinion exceeds a fixed threshold. We consider applying our methods on real social network in Twitter with hundreds of thousands of individuals.

2 - Assessing the Impact of Bots on Opinions in Social Networks

Nicolas Guenon des Mesnards, Massachusetts Institute of Technology, 143 Albany St, Cambridge, MA, 02139, United States

We develop a method to assess the impact of bots in social networks. We assume user opinions are in an equilibrium based on a generalized opinion dynamics model with stubborn users who have immutable opinions. We use an algorithm based on the Ising model to identify bots in networks and calculate the equilibrium mean opinion with and without the bots. The shift in this mean provides a measure of the impact of the bots. We apply our method to Twitter users discussing Brexit and the Gilets Jaunes protests. We find that the bot impact varies greatly in these datasets.

3 - Running Influence Campaigns on Social Media

Tauhid Zaman, MIT, Boston, MA, 02114, United States

We conduct a field experiment in Twitter to understand how to influence users on the topic of immigration. We consider to what degree the opinions of Twitter users can be influenced by mutual followers. We consider how the effectiveness of influencers vary across several dimensions including race, shared group identity, and social rapport between users. We measure influence through the change of language used by the subjects on social media. Through this, we draw conclusions on the effectiveness of peer influence on Twitter in changing opinions on a politically heated topic.

4 - Twitter-based Cyber Security Warning and Prioritization System

Enhao Liu, Graduate Research Associate, Ohio State University, Columbus, OH, United States

Cyber vulnerability management continues to be an important topic in companies even with the emphasis on resilience. Using Twitter predictions of local incident counts in advance are possible from time series models. Also, classification models can identify the likely key vulnerabilities involved. We describe briefly the models, features, and implications.

■ WB11

CC- Room 214

Queueing Approximations and Strategic Queues

Sponsored: Applied Probability

Sponsored Session

Chair: John Hasenbein, University of Texas-Austin, Austin, TX, 78712-0292, United States

1 - A Fluid-diffusion-hybrid Limiting Approximation for Priority Systems with Fast and Slow Customers

Lun Yu, Northwestern University, Evanston, IL, 60208, United States, Seyed Iravani, Ohad Perry

Motivated by emergency departments, we consider a priority queueing system with two customer classes; the first class (of "high acuity") requires long service times and receives priority over the second class (of "low acuity"), whose average service times are substantially shorter. Unfortunately, the dynamics of such a system are intractable, and existing heavy-traffic regimes cannot capture the fact that, in practice, a non-negligible proportion of the arrivals from either class must wait for service. We propose a Fluid-Diffusion Hybrid limit to approximate the two queues, and demonstrate how it can be employed to study the benefits of de-pooling (namely, of having a "fast-track").

2 - Dynamic Pricing in a Robust Naor's Model

John Hasenbein, University of Texas-Austin, 1 University Station Stop C2200, Department of Mechanical Engineering, Austin, TX, 78712-0292, United States, jhas@mail.utexas.edu

We investigate a version of Naor's model with dynamic pricing, heterogenous customers, and an uncertain arrival rate. We solve the pricing problem from a robust viewpoint, in the process developing robust Bellman equations and a modified value iteration algorithm.

3 - The Supermarket Game with Finitely Many Servers

Ran Snitkovsky, Tel Aviv University, Tel Aviv, 6997712, Israel, ransnit@gmail.com, Hassin Refael

Homogeneous customers with exponentially-distributed service demand arrive following a Poisson process at a service facility with N different single-server queues. Upon arrival, each customer randomly inspects a given number out of the N queues and joins the shortest one. Customers incur a fixed inspection cost per queue and linear waiting costs, and wish to minimize their total expected cost. Xu and Hajek (2013) named this model the Supermarket Game and applied a mean field approach to study the game when the number of servers, N, approaches infinity. We discuss the case of finite N and in particular, derive analytic results for N=2.

4 - Effects of Patient Heterogeneity on the Patients' Choice in a Transplantation System

Chia-Hao Chang, The University of Texas at Austin, Austin, TX, United States, chchangkh@utexas.edu, John Hasenbein

In this work, we study the patient's strategic behavior in a transplantation system. Specifically, we model the system as an M/M/1 queue, where both patients and organs arrive as a Poisson process. Each patient is allowed to accept or decline an organ offer in his own interest. In this regard, the problems is modeled as a Markov decision process. We study how the patient's heterogeneity may influence each individual's decision. We also compare how different system parameters may affect the patient's choice.

■ WB12

CC- Room 2A

Stochastic Networks Asymptotics

Sponsored: Applied Probability

Sponsored Session

Chair: Rami Atar, Technion, Haifa, 32000, Israel

1 - Heavy Traffic Limit for Ridesharing Systems

Amir A. Alwan, PhD. Student, University of Chicago Booth School of Business, Chicago, IL, United States, amir.alwan@chicagobooth.edu, Baris Ata

We model a ridesharing system as a queueing network with service and travel nodes, where service nodes correspond to regions of the city and travel nodes help model travel time between service nodes. We establish a heavy traffic limit for the system state.

2 - Many-server Asymptotics for Join-the-shortest-queue: Large Deviations and Rare Events

Eric Friedlander, University of Chicago, 110A Crest Street, Chicago, IL, 27510, United States, efriedlander@uchicago.edu, Amarjit Budhiraja, Ruoyu Wu

We study the Join-the-Shortest-Queue load balancing policy in an asymptotic regime where the number of processors, n, scales with the arrival rate. Letting Xin(t) denote the proportion of queues with i or more jobs at time t, we establish a large deviation principle (LDP) for Xn=(X1n, X2n, ...), as n ∞. Some of the technical obstacles in the proof will be discussed, as well as implications of the result. In particular, we address how the LDP can be used to estimate rates of decay for probabilities of rare-events, such as long-queues.

3 - Functional Limits for Markov Modulated Stochastic Fluid Flow Models

Harsha Honnappa, Purdue University, West Lafayette, IN, 47906, United States, honnappa@purdue.edu, Prakash Chakraborty

We propose a model of a stochastic fluid flow system where the cumulative stochastic fluid input is modeled by the integrated number of occupied servers of a loss model with non-stationary and Markov modulated arrivals. General service times and the fixed system size pose serious challenges in analyzing server occupation, and forms a complicated interacting particle system. Under mild conditions we obtain functional fluid and diffusion limits as the system size scales to infinity for the number of occupied servers in the loss system and the corresponding integrated process. Our results also suggest a propagation of chaos type result suggesting asymptotic independence of the servers.

4 - Robustness via Renyi Divergence, with Applications to Queueing

Rami Atar, Technion, Department of Electrical Engineering, Haifa, 32000, Israel

This talk describes a recently developed approach to large deviation (LD) estimates on probabilistic models that are uniform within families of underlying probabilistic primitives. The approach is based on defining these families in terms of Renyi divergence. Advantages of the approach are that it (1) provides effective bounds on hard models (including ones for which the LD principle is not known to hold), (2) explicitly quantifies robustness of these estimates to distributional perturbations. After the introduction of the main ideas, the talk will focus on applying them to queueing models. The talk is based on joint work with Amarjit Budhiraja, Paul Dupuis and Ruoyu Wu.

■ WB13

CC- Room 2B

Advances in Data Driven Theory and Models

Sponsored: Applied Probability

Sponsored Session

Chair: Floske Spieksma, Leiden University, Leiden, Netherlands

Co-Chair: Michael N. Katehakis, Rutgers University, Newark, NJ, 07010, United States

1 - Non-parametric Up-and-down Experimentation Re-revisited

F. M. Spieksma, Leiden University, Leiden, Netherlands, Sheldon M. Ross, Michael N. Katehakis

We consider an experiment that can be run at levels 1, 2, ..., n. When it is run at level i it is a success with probability p_i, where the p_i are increasing in i, and unknown. In applications, p_i might be the cure probability when i units of a medication are used. We are interested in the smallest dosage i^* with a cure probability that is greater than a fixed target value. We discuss alternative sequential estimation methods of i^* with fast convergence properties.

2 - Some New Policies for Selecting the Best Population

Sheldon M. Ross, Universit of Southern California, Los Angeles, CA, 90089, United States, M. Javad Azizi, Y. .Cao

We consider the problem of selecting the best population, both in the Bernoulli and normal case. One objective considered is to minimize the expected selection time subject to an upper bound on the probability of making a wrong choice; another is to maximize the probability of correct choice when the time horizon is fixed.

3 - Fatou's Lemma in its Classic Form for Varying Measures with Applications to MDPs

Yan Liang, University of Toronto, Toronto, ON, Canada, Eugene A. Feinberg, Pavlo O. Kasyanov

This paper provides sufficient conditions when Fatou's lemma holds in its classic form for a sequence of weakly converging measures. In general, Fatou's lemma for a sequence of weakly converging measures states a weaker inequality than the classic one because the integral of the lower limit should be replaced with the integral of the lower limit in two parameters, where the second parameter is the argument of the functions. The obtained results are used to prove broad sufficient conditions for the validity of optimality equations for average-cost Markov decision processes. In particular, these conditions hold for classic inventory control problems.

4 - Accelerated Linear Convergence of Stochastic Momentum Methods in Wasserstein Distances

Mert Gurbuzbalaban, Rutgers University, Newark, NJ, United States, Bugra Can, Lingjiong Zhu

Momentum methods such as Polyak's heavy ball (HB) method, Nesterov's accelerated gradient (AG) as well as accelerated projected gradient (APG) method have been commonly used in machine learning practice, but their performance is quite sensitive to noise in the gradients. We study these methods under a first-order stochastic oracle model where noisy estimates of the gradients are available and obtain a number of fast convergence results in the Wasserstein metric for both stochastic convex and strongly convex optimization.

■ WB14

CC- Room 302

Adaptive Analytics: Effects on Business and the Supply Chain

Sponsored: Manufacturing & Service Oper Mgmt

Sponsored Session

Chair: Clark C Pixton, Brigham Young University, Brigham Young University, Provo, UT, 84601, United States

1 - Variance-Damping or Variance-Amplifying? A Look at Analytics in the Supply Chain

Clark C. Pixton, Brigham Young University, Provo, UT, 84601, United States, cpixton@byu.edu

We introduce a framework, based on the stochastic optimization paradigm, which allows for analysis of the externalities of implementing adaptive analytics. Specifically, we show that when feature-based prediction becomes an input into a decision process, such as an order quantity or pricing decision, it may have either a positive or negative effect on upstream decisions. We discuss operational and strategic implications.

2 - Double Dipping of Two-Sided Platform Economy

Satyanath Bhat, National University of Singapore, Singapore, satya.bhat@nus.edu.sg, Jussi Keppo, Chung Piaw Teo

The role of platforms in breaking traditional monopolies, creating new markets, and resulting increase in social welfare is overwhelmingly positive. We examine a two-sided platform economy against a more stricter benchmark —- an open platform that discloses its proprietary information. We show that, due to the big proprietary data the platforms control, they can be detrimental to both sides of the market resulting in social welfare losses compared to the benign open platform.

3 - Menu Costs and the Bullwhip Effect: Supply Chain Implications of Dynamic Pricing

Ioannis Stamatopoulos, University of Texas at Austin, McCombs School of Business, 2110 Speedway B6000, Austin, TX, 78705, United States, yannis.stamos@mccombs.utexas.edu, Robert Louis Bray

We study the supply chain implications of dynamic pricing. Specifically, we estimate how reducing menu costs — the operational burden of adjusting prices — would affect supply chain stability.

■ WB15

CC- Room 303

Decision Analysis I

Contributed Session

Chair: Alireza Lari, Wake Forest University, Cary, NC, 27518, United States

1 - Extracting Latent Information Sources from Dependent Distributional Forecasts

Yuanyuan Lei, Tsinghua University, Beijing, China, leiyy17@mails.tsinghua.edu.cn

Traditional aggregation in forecasts often ignores the judges' correlation, which can be attributed to the shared-information problem. In this study, we propose a functional analysis model about quantile predictions on a continuous uncertain quantity, in which the predictive function is represented by a Gaussian process and its mean is a linear combination of independent and orthogonal cues function. The estimated weights reveal information utilizing and can be used to group experts. Thus we can explore the relationship between experts and construct an optimization for the expert grouping and weight assigning to groups (if historical data is available), which is more stable for aggregating.

2 - A Two Phase Framework of Project Portfolio Selection and an Empirical Study in the Integrated Circuit Design Company

Kang-Ting Ma, National Tsing Hua University, Hsinchu, Taiwan, Chen-Fu Chien

The semiconductor industry is capital intensive, and Integrated Circuit design company plays an important role in leading the industry chain to migrate to new technologies and to develop variety of applications. Project portfolio selection in Integrated Circuit design company is important to maintain the competitiveness by considering profitability, and resources utilization. This paper aims to propose a two phase framework, which incorporates the project evaluation phase by the data envelopment analysis, and project portfolio selection phase by a mathematical programming. An empirical study is conducted in a Integrated Circuit company, and results show the decision quality is improved.

3 - Analysis and Prediction of Airline Delay

Alok Dand, Wichita State University, Wichita, KS, United States, axdand@shockers.wichita.edu, Khawaja Saeed, Bayram Yildirim

Supply chains are impacted greatly by airline delays and cancellation. With around 20% of domestic flights being impacted each year, the costs to passengers, airline companies and the economy are in billions of dollars each year. With an estimated 50% increase in the people traveling via airlines in the next 2 decades, a thorough examination of the different trends and impact of different airline company controlled variables and uncontrollable variables is essential. Different machine learning algorithms are then used to predict delays which are compared using recall rates and ROC-AUC score.

4 - Opportunities and Challenges for Cost Management by Optimizing Benefits of Workers of a Collective Agreement

Rodrigo Barraza, Universidad Santo Tomas, Santiago, Chile, rodrigobarrazaal@santotomas.cl, Juan Venegas

This article proposes a framework consisting of an optimization model and an application that allows designing and executing instances of analysis to optimize the benefits of union workers in a company providing services to the mining industry. However, both collective bargaining processes and the execution of collective bargaining agreements over time present fluctuations in costs, which have a negative impact on the management of the collective bargaining agreement and, finally, on the appropriate allocation of benefits for workers. We purpose a framework to analyze optimal instances of collective bargaining agreements of a worker's union.

5 - Which Channel Improvement Project to Invest In? A Case Study

Yasamin Salmani, Bryant University, Smithfield, RI, United States, Fariborz Partovi, Avijit Banerjee

In this study, an investment model towards improving channel structures, in a multi-channel multi-product setting, is reviewed. The focus of this study is the application of the proposed methodology in a U.S. manufacturing company.

6 - Introducing Business Analytics in an Overseas Car Manufacturer to Improve Business Processes

Alireza Lari, Teaching Professor, Wake Forest University, Winston Salem, NC, United States, Nasim Lari

To improve process efficiency and data-driven decision-making, PKH committed to leveraging business analytics. This required establishing data governance best practices, data architecture, introduction of analytics methods, and management science. Preliminary evaluations demonstrate improved process optimization, prediction of equipment failure and production breakdowns, reduction of quality costs, and increase in customer and employee satisfaction. This paper highlights the successful implementation of analytics in an environment with significant limitations.

■ WB16

CC- Room 304

Innovations in Teaching Service Operations

Sponsored: Manufacturing & Service Oper. Mgmt/Service Operations

Sponsored Session

Chair: Ryan Buell, Harvard Business School, Boston, MA, 02163, United States

1 - Finding Your Teaching Style in the MBA Classroom

Maria R. Ibanez, Kellogg School of Management at Northwestern University, 2211 Campus Drive, Evanston, IL, 60208, United States

We will discuss teaching methods and experiences, including tips for future MBA instructors.

2 - Bringing Experiential Learning into The Classroom

Amrou Awaysheh, Indiana University, Indianapolis, IN, 28006, United States, awaysheh@iu.edu

Experiential Learning (EL) gives students the opportunity to learn through doing. We will discuss some strategies for incorporating EL in the MBA classroom.

3 - Incorporating Research into Teaching

Yasin Alan, Vanderbilt University - Owen Graduate School of Management, 401 21st Avenue South, Nashville, TN, 37203, United States, yasin.alan@owen.vanderbilt.edu

In this talk, I will discuss my efforts to incorporate research findings into case discussions. I will provide a few specific examples from the MBA-level courses I teach at Vanderbilt.

4 - Teaching Experimentation in Service Operations

Ryan Buell, Harvard Business School, Boston, MA, 02163, United States

In 2017, Commonwealth Bank of Australia was seeking to differentiate itself from other banks, and to improve the financial wellbeing of its customers. To that end, managers had developed a provocative experiment dubbed "The Good and the Bad." Rather than just presenting the strengths of its credit card offerings, they proposed also promoting each credit card's drawbacks. Being transparent with customers might help them make better choices, but would those choices come at the expense of bank performance? The case helps students think through the process of incorporating experimentation into service operations - from idea generation, to execution, to evaluation.

■ WB17

CC- Room 305

MSOM Service SIG

Sponsored: Manufacturing & Service Oper. Mgmt/Service Operations

Sponsored Session

Chair: Nicholas A Arnosti, Columbia Business School, New York, NY, 10027, United States

1 - Optimal Commissions and Subscriptions in Networked Markets.

Hongfan Chen, University of Chicago, Chicago, IL, 60615, United States, hongfan.chen@chicagobooth.edu, John R. Birge, Ozan Candogan, Daniela Saban

Two salient features of most online platforms are that they do not dictate the transaction prices, and use commissions/subscriptions for extracting revenues. We shed light on how these commissions/subscriptions should be set in networked markets. We provide a tractable convex optimization formulation to calculate the revenue-maximizing commissions/subscriptions. Motivated by simpler schemes used in practice, we show that the revenue loss can be unbounded when all traders on the same side are charged the same commissions/subscriptions. Charging only buyers or only sellers leads to at least half of the optimal revenues, when different types on the same side can be charged differently.

2 - Food waste

Elena Belavina, Cornell University, Ithaca, NY, United States

Roughly 1/3 of all food produced in the world is wasted. All this wasted food represents carbon emissions that could have been avoided. In this talk we will explore the biggest culprits and what could be done to reduce food waste.

3 - On the Optimal Design of a Bipartite Matching Queueing System

Philipp Afeche, University of Toronto, Rotman School of Management, 105 St. George Street, Toronto, ON, M5S 3E6, Canada, afeche@rotman.utoronto.ca, Rene A. Caldentey, Varun Gupta

We study the design of optimal matching topologies between customer classes and servers for a multi-class multi-server queueing system with a FCFS-ALIS service discipline. We aim to identify topologies that optimize - in a Pareto efficiency sense - the trade-off between two competing objectives: (i) minimizing customer waiting times and (ii) maximizing matching rewards generated by pairing customers and servers. To this end we show that in heavy traffic, for any matching topology the scaled steady-state waiting times are determined via an intuitive partition of interconnected subsystems, and the matching rates are very well approximated via a quadratic flow maximization program.

4 - A Continuum Model for Stable Matching with Finite Capacities

Nick Arnosti, Columbia Business School, New York, NY, 10027, United States

Stable matching algorithms are used to clear many markets — most notably, for residencies and public schools. However, the literature relating outcomes to market primitives is sparse, and often makes very restrictive assumptions such as uniform random preferences. We introduce a continuum model that allows for arbitrary capacities, preferences, and priorities, and show that it always has a unique stable outcome. The model accurately predicts simulation outcomes from the literature, even for markets with as few as ten or or twenty participants on each side. We illustrate the usefulness of the model by proving several new results.

■ WB18

CC- Room 306

Joint Session MSOM/SC/Practice Curated: Omni-channel Retail Operations

Sponsored: Manufacturing & Service Oper. Mgmt/Supply Chain

Sponsored Session

Chair: Stanley Lim, University of San Diego, Tempe, AZ, United States

Chair: M. Serkan Akturk, Clemson University, Clemson University, Clemson, SC, 29631, United States

1 - The Effect of Offering Additional Fulfillment Options

Chloe Kim Glaeser, University of North Carolina, Kenan-Flagler Business School, 714 Greenwood Rd, Chapel Hill, NC, 27514, United States, chloe_glaeser@kenan-flagler.unc.edu, Kenneth Moon, Xuanming Su

We partner with an online grocery retailer to answer the practice-based question of the optimal mix of delivery zones and fulfillment options using data-driven analytics. We investigate how consumers respond to the locally tailored fulfillment options made available to them by the online grocer. We employ a geographical regression discontinuity design to find the causal effect of delivery introduction.

2 - Should Omnichannel Retailers Allow in Store Returns of Online Purchases?

Punya Chatterjee, Penn State University, University Park, PA, United States, pxc85@psu.edu, Aydin Alptekinoglu, Nicholas C. Petruzzi

We investigate when an omnichannel retailer should allow in-store returns of online purchases. The retailer has two substitutable products to offer, both available online, that differ by the uncertainty consumers have over their valuation. The retailer sets prices and store assortment in addition to the store return policy.

3 - Lead Time and Demand Sensitivity: Implications for Omni-channel Facility Network Design

Stanley Lim, University of San Diego, San Diego, CA, United States, stanleylim@sandiego.edu, Fei Gao, Fangyun Tan

Previous research on showrooms in retailing typically differentiates the showroom channel from the online channel only in terms of information delivery. It implicitly assumes that consumers have homogeneous preference in product fulfillment across channels. That is, the showroom demand is assumed to have the same elasticity/sensitivity to delivery lead time as demand in the other channels. We empirically examine this assumption and the channel-specific effects of lead time on demand. We further incorporate our findings into the design of an omni-channel retailer's facility network in terms of decisions about the quantity and size of the showrooms.

4 - Assessing the Value of Launching Omnichannel Retailing Practices

M. Serkan Akturk, Assistant Professor, Clemson University, Department of Management, Sirr 374A Sirrine Hall, Clemson, SC, 29631, United States, makturk@clemson.edu

Recent changes in the shopping journey of customers arising from technological advancements, increasing use of smartphones, and continuous access to internet force retailers to integrate their existing channels by offering omnichannel service processes such as buy-online and pick-up-in-store or ship-to-store. Using a proprietary transaction level dataset from a U.S. based retailer, we explore the impact of launching omnichannel service offering across both online and offline channels. Our findings are extensive and provide managerial insights in the omnichannel retail operations domain.

■ WB19

CC- Room 307

Behavioral Operations II

Contributed Session

Chair: Daniel Hernando Romero, Universidad Del Norte

1 - Air Pollution and Green Consumption of Consumers in China's Urban Areas: A Norm Activation Perspective

Ruiju Yang, University of Science and Technology of China, Hefei, China, yangruij@mail.ustc.edu.cn

This study explores how consumers' psychological factors affect their green purchasing behaviors during a city smog. Using a questionnaire survey involving 1124 participants living in the Beijing-Tianjin-Hebei region of China, we found the following results. First, product knowledge, smog knowledge, risk perception, and systematic processing positively influence consumers' purchase intentions of green anti-smog products. Second, consumers' personal norms significantly affect their green purchase decisions. This study provides practical guidance for marketing management and helps managers gain accurate insight into consumer behavior in a crisis situation.

2 - Team Composition Considering Individual Differences in Pacing Styles

Tianchen Sun, University of Washington, Seattle, WA, United States, Ji-Eun Kim

Pacing style refers to the distribution of individuals' efforts over time as deadlines approach; some individuals start their work early, while others do not start their work until the deadline. Researchers have conceptualized and modeled individual differences in pacing styles (IDPS); however, effective composition of teams accounting for such differences have not been clearly identified. In this study, we collected students' online activities on course websites and explored the relationship between the level of pacing style diversity within individual teams of students and team performance. This research elucidates improved practices for team formation.

3 - How to Develop Effective Systems Engineers?

Morteza Nagahi, Mississippi State University, Starkville, MS, United States, mn852@msstate.edu, Niamat Ullah Ibne Hossain

This research introduces a new system engineering instrument that assesses the performance of systems engineers based on the set performance indicators of six fundamental system engineering attributes. This instrument would serve a baseline to understand the current state of the skill of individual system engineers. The paper is structured to explore four primary areas. First, we examine why there is a need to develop effective systems engineers. Second, we proposed a novel tool that could aid in developing effective systems engineers. Next, we present an examination of the individual performance of induvial systems engineers, followed by the implications of the proposed instrument.

4 - Productivity Implications of Diversity of Experience in Fluid Teams

Antti Tenhiala, IE Business School, Madrid, Spain, antti.tenhiala@ie.edu, Constantin Alba, Fabrizio Salvador

How does team diversity in past work experience influence project productivity? We study this question using work assignment data from a multinational software services firm. We operationalize diversity of experience along three dimensions: the variety of specializations, separation of experience profiles, and disparity of expertise. We hypothesize and observe distinct curvilinear productivity effects for each dimension. We further theorize that project complexity moderates the hypothesized relationships and observe differences in each dimension up to the reversal of the productivity effect between projects of low and high complexity.

5 - Resilience Assessment in Social Systems: Applications in Communities, Sports and Education

Daniel Hernando Romero, Universidad Del Norte, Barranquilla, Colombia, hromero@uninorte.edu.co, Weimar Ardila, Alex Savachkin

Resilience assessment in social, physical and cyber systems has offered multiple metrics, definitions and dimensions, but there is still a lack of consensus in how to capture it. This presentation offers an overview of resilience measurements and drivers identification in social systems. A community affected by pandemic influenza, teams abilities to comeback when facing a scoring disadvantage in sports, and students ability to recover when the cumulative grade is not satisfactory to pass a grade, are three applications to showcase different settings where resilience can be explored.

■ WB20

CC- Room 308

Using OR/Analytics Methods to Assess and Improve Performance of Higher Education

Contributed Session

Chair: Philip Schuyler Baxa, United States Coast Guard, Gales Ferry, CT, 06335, United States

1 - Artificial Intelligence and its Applications in Higher Education: A Synthesis

SeokJoo Kwak, University of Michigan, Ann Arbor, MI, United States, seokjook@umich.edu, Joi-Lynn Mondisa

Current issues of formidable inequities in the quality of higher education are matters of institutional and system reform of our society which are directly connected with future employment and generations. Furthermore, future generations will be significantly impacted by technological advances such as Artificial intelligence (AI). The purpose of this paper is to synthesize details about the evolution and development of AI, identify the role and impact of AI in higher education, and speculate about the future of AI in higher education.

2 - Managing Yield-uncertainty Caused by Randomness and Subsequent Withdrawals in Academic Admissions

Subhamoy Ganguly, University of Auckland, Auckland, New Zealand, s.ganguly@auckland.ac.nz, Ranojoy Basu, Viswanathan Nagarajan

Admissions to academic programs often involve filling seats by making offers to a rank-ordered list of applicants, but only a fraction of those receiving offers end up enrolling. We develop an analytical model to arrive at the number of offers to make while considering the expected costs of exceeding or falling short of the target enrollment. The model generates interesting insights and is validated using a large multi-year empirical data set of applications and admission offers for an MBA program.

3 - Performance Evaluation and Enrollment Quota Allocation for Higher Education Institutions in China

Ganggang Zhang, University of Science and Technology of China, Hefei, China, ggz1616@mail.ustc.edu.cn

The rapid economic growth has brought China's higher education into a new stage. However, the uneven development of higher education in different provinces has become a critical factor restricting China's overall progress. We propose a Data Envelopment Analysis approach to evaluate the efficiency of higher education resource utilization in provinces of China. We assess the productivity changes of each province with the help of the Malmquist productivity index. By considering the enrollment quota as a resource, we construct a reasonable allocation scheme. Suggestions are put forward to help the Chinese government better solve the unbalanced development of higher education among provinces.

4 - Predictive Modeling of the U.S. Coast Guard Academy Graduating Class

Philip S. Baxa, Mathematics Instructor, United States Coast Guard Academy, New London, CT, United States

The U.S. Coast Guard Academy (USCGA) has developed leaders of character who embody Coast Guard values since 1876. This project assessed the USCGA's training and education program by analyzing historical cadet data to forecast the composition of the graduating class by analyzing the attributes of the incoming class, and attributes (e.g. GPA, demerits, physical fitness scores, and athletic, clubs and activity participation) that are accumulated over the course of a cadet's career. This research supported the USCGA's Strategic Plan and analyzed the relationship between the intended majors of applicants, the migration of cadets between majors, and the degree a cadet ultimately completes.

■ WB21

CC- Room 309

Systemic Risk

Sponsored: Finance

Sponsored Session

Chair: Mike Ludkovski, University of California-Santa Barbara, Santa Barbara, CA, United States

Chair: Nils-Christian Detering, University of California-Santa Barbara, University of California-Santa Barbara, Santa Barbara, CA, 93106-3110, United States

1 - Incorporating Confidence into Systemic Risk

Maxim Bichuch, Johns Hopkins University, Dept of Applied Mathematics and Statistics, Johns Hopkins University, Baltimore, MD, 21218, United States, Ke Chen, Zachary Feinstein

In a crisis, to raise funds, banks can sell their shares in the market and borrow money. We propose a simple model that incorporates market confidence to find the maximum amount of new funds the banks can raise in this way. Additionally, for a given shortfall, we find the optimal mix of borrowing and stock selling. We show the existence and uniqueness of Nash equilibrium strategy, and calibrate this model to market data. In a related model of financial contagion in a network subject to fire sales and price impacts, we give sufficient conditions for existence and uniqueness of the clearing solutions (i.e. the Nash equilibrium of an aggregation game).

2 - Numerical Methods in Mean-field Game for Large Banking System with Defaults

Tomoyuki Ichiba, University of California-Santa Barbara, South Hall 5607A, Santa Barbara, CA, 93106, United States, ichiba@pstat.ucsb.edu

We consider the dynamics of the cash reserves of an interconnecting banking system. Whenever a bank defaults (by letting its reserve reach a given threshold), each bank is impacted negatively, via an instantaneous jump on its reserve level. We also take into account the arrival of new financial institutions in the system. Under such setup, we discuss numerical methods to solve the mean-field game and identify the resulting dynamics as the equilibrium among banks in interaction. Part of research is joint work with R. Elie and M. Lauriere.

3 - Suffocating Fire Sales

Nils Detering, University of Califnornia-Santa Barbara, Santa Barbara, CA, United States

In this paper we develop models that allow us to investigate central characteristics that drive the propagation of distress through fire sales in financial systems. We investigate single systems as well as ensembles of systems that are alike, where similarity is measured in terms of the empirical distribution of defining properties of a system. A natural characterization of systems resilient to fire sales emerges. We propose minimal capital requirements, investigate the effect of portfolio diversification and quantify the trade-off between objectives for classical single firm risk management and those for systemic risk management.

4 - Measuring Risks in Hedge Funds: Evaluation and Usefulness of Exposure Data in Form PF

Stathis Tompaidis, University of Texas-Austin, McCombs School of Business, IROM Department, Austin, TX, 78712-1179, United States, Stathis.Tompaidis@mccombs.utexas.edu, Phillip Monin, Matthew Pritsker

We use data from a new regulatory filling for large hedge funds, Form PF, to evaluate the accuracy of reported stress test exposure information and to construct measures of hedge funds' aggregate risk. At the individual fund level, we find the exposure information has weak power to explain individual fund returns. However, aggregating the reported stress test results by groups or for the entire set of reporting funds improves the situation significantly. We build two aggregate measures of risk and decompose the contributions to these measures by fund strategy and fund liquidity. Our results can be used to improve the form and to monitor aggregate risk across reporting funds.

■ WB22

CC- Room 310

Topics in Sustainable Operations

Sponsored: Manufacturing & Service Oper. Mgmt/Sustainable Operations

Sponsored Session

Chair: Ximin Huang, University of Minnesota, Minneapolis, MN, 55455, United States

1 - Fleet Refresh Decisions in Car-sharing Business Models

Ximin Natalie Huang, Assistant Professor, University of Minnesota, 321 19th Ave S, Ste 3-150, Minneapolis, MN, 55455, United States, huangx@umn.edu, Vishal Agrawal, Ioannis Bellos

We study how car-sharing service offerings should be managed along with produce sales. We focus on an important decision, namely how often to refresh the car-sharing fleet, as it influences both the primary and secondary market. We also explore these decisions for a third-party car sharing provider competing with sales.

2 - We Are on the Way: Analysis of On-demand Ride Hailing Platforms

Guiyun Feng, Singapore Management University, Singapore, Singapore, Guangwen Kong, Zizhuo Wang

The rapid rise of on-demand ride-hailing platforms has raised questions about how such a new matching mechanism will affect the efficiency of the transportation system. In this paper, we shed light on this question by building a stylized model of a circular road and comparing the average waiting times of passengers under various matching mechanisms. We discover the inefficiency in the on-demand ride-hailing system when the en route time is long, and find that the on-demand matching mechanism could result in lower efficiency than the traditional street-hailing mechanism in some scenarios.

3 - Green Farming: the Interaction of New Technologies, Consumer Preferences and Contract Choices

LI Dong, Lingnan (University College), Sun Yat-Sen University, Guangzhou, China, lidong9@mail.sysu.edu.cn, Saif Benjaafar, Niyazi Taneri

Over half of all farmland in some US states are operated by farmers who are not the landowner. New technologies such as sensors, drones, satellite imaging, and cloud computing promise to enable the landowner to monitor farmers' efforts and alleviate the hidden action problem. In the context of green farming, we generate analytical insights that result from the interaction of consumer preferences, contracting decisions and these emerging technologies.

■ WB23

CC- Room 3A

Advances in Decision Modeling

Sponsored: Decision Analysis

Sponsored Session

Chair: Ahti Salo, Aalto University, Aalto University, Aalto SCI, 00076, Finland

1 - A Multi-objective Decision Support Tool for Cooperative Duty Rostering

Antti Punkka, Aalto University, Systems Analysis Laboratory, Aalto SCI, 00076 Aalto, Espoo, Finland, antti.punkka@aalto.fi, Aleksi Porokka

We develop a rostering tool, which produces cost-efficient, personalized, 3-week long rosters for Finnish train drivers. The optimization model for producing the rosters is based on maximizing additive multi-attribute value subject to constraints set by law, collective bargaining, equal treatment of drivers and their personal competences and preferences. The model considers many aspects of drivers' well-being, which makes trade-offs between cost-efficiency and drivers' well-being transparent. We discuss how the tool improved the rosters' cost-efficiency and enhanced the interaction between the driver representatives and the roster planners through cooperative, iterative planning.

2 - Decision Programming for Optimizing Multi-Stage Decision Problems under Uncertainty

Fabricio Oliveira, Aalto University School of Science, Espoo, Finland, fabricio.oliveira@aalto.fi, Ahti Salo, Juho Andelmin

We develop the Decision Programming approach for solving multi-stage decision problems which can be represented as extended influence diagrams where the 'no forgetting' assumption need not hold. This approach can handle multiple objectives and different risk measures, including VaR and CVaR. It can also be viewed as an extension of Contingent Portfolio Programming (Gustafsson and Salo, Oper. Res., 2005) for selecting projects which can influence scenario probabilities. We show that problems of realistic size can be efficiently solved as mixed-integer linear programs strengthened by probability cuts.

3 - The Efficient Frontier Based on Second- and Third-order Stochastic Dominance

Juuso Ilari Liesio, Aalto University School of Business, Finland, juuso.liesio@aalto.fi

Stochastic dominance provides decision recommendations among portfolios of assets with uncertain outcomes (e.g., investments, projects or stocks) without requiring exact specification of risk preferences. We develop models to identify the set of portfolios that are efficient in the sense of second- or third-order stochastic dominance. These models provide novel insights into the composition of portfolios belonging to the efficient frontier. Moreover, the identification of the efficient frontier makes it possible to utilize additional information on the decision maker's risk preferences to further reduce the set of admissible portfolio alternatives.

4 - Analytic Method for Identifying and Visualizing a Diverse Set of Plausible Scenarios for Strategic Planning

Teemu Seeve, Aalto University School of Business, Espoo, Finland, teemu.seeve@aalto.fi, Eeva Vilkkumaa

In uncertain future operational environments, consideration of alternative scenarios can support strategic planning of organizations. Scenarios can be modeled as combinations of levels on multiple uncertainty factors describing, e.g., technological and economic developments. We develop an efficient algorithm to filter the most plausible out of exponentially many candidate scenarios, and a visualization method to support the identification of a diverse set of plausible scenarios. This method is applied to a real case in developing scenarios for the National Emergency Supply Organization in Finland.

■ WB24

CC- Room 3B

Decision and Risk Analysis in a Digital Era

Sponsored: Decision Analysis

Sponsored Session

Chair: Jun Zhuang, University at Buffalo, SUNY, Buffalo, NY, 14260, United States

1 - Cognitive Consistency and Confirmation Bias in Deception Detection of False Information in Social Media Following Extreme Events

Richard S. John, Professor, University of Southern California, Dept of Psychology MC 1061, Los Angeles, CA, 90089-1061, United States, richardj@usc.edu, Katie Byrd

Social media has become a critical source of information following extreme events. Such communication is often hindered by false and deceptive posts. I report behavioral research on detection of false information in social media immediately following natural disasters and soft target terrorist attacks. Detection performance is evaluated within a Signal Detection Theory (SDT) framework by manipulating both base-rates and error penalties. Detection biases are identified and related to individual cognitive, motivational, and personality factors. Both utcome feedback and critical thinking training are evaluated independently and jointly as possible interventions to improve performance.

2 - A Blockchain Framework to Improve Emergency Communications

Kyle J. Hunt, Student and Research Assistant, University at Buffalo, Buffalo, NY, 14221, United States, kylehunt@buffalo.edu, Jun Zhuang

In recent years, research has studied the spread of fake news and misinformation during natural disasters, elections, and terrorist events across social media and even emergency alert systems. Besides the worries regarding content veracity, the timeliness of information is of the utmost concern in crisis communications and emergency management. In this work, we study the application of blockchain to improve crisis communications. We propose a framework to create safer, quicker, and more reliable communication networks in times of natural disasters, terrorism events, and other hazardous situations.

3 - Estimating Strategic Catastrophe Insurance Demand with Social Media Data Analysis

Shenming Song, Tsinghua University, Beijing, 100084, China, Chen Wang, Shu Huang

We consider the leader insurers who are involved in the risk sharing partnership mandatorily but require the additional regulatory cost, and the follower insurers who choose to join the partnership voluntarily but probably need incentive. To deal with the fluctuations in catastrophe insurance demand, this research proposes a social learning model to elicit the time-varying purchase utility by using repost and review data in online social networks. We then characterize the government dynamic schemes about whether targeting on the leader or follower insurers given the population dynamics.

4 - Application of Social Media Image Classification to Detect Infrastructure Damage During Natural Disasters

Ridwan Al Aziz, State University of New York-Buffalo, Buffalo, NY, 14260, United States, ridwanal@buffalo.edu, Puneet Agarwal, Nafisa Mahbub, Qing He, Jun Zhuang

During natural disasters, it generally takes a substantial amount of time for humanitarian organizations to assess the damages caused by them. As image-based social media platforms like Instagram and Flickr have become very popular to the mass people, they can be viewed as a fast and easily accessible source for image data at a relatively lower cost. In this paper, different machine learning algorithms are applied to a dataset developed by retrieving infrastructure damage related images during disasters. Among the five approaches, Convolutional Neural Network is identified as the most efficient approach and hence, provides an inexpensive and faster alternative in real time damage detection.

5 - Understanding Information Diffusion in Social Media in a Hurricane Evacuation Context

Kamol Chandra Roy, University of Central Florida, Orlando, FL, United States, Samiul Hasan

Using online social network, one can now communicate with thousands of other people that may shape their evacuation decisions. In this study, we use Twitter data to study the dynamics of warning information propagation through social media. We also study how information propagation affects individual evacuation decisions. Finally, we jointly model the information propagation and evacuation decision dynamics using an epidemic modeling approach. The findings of our study will reveal the effects of network structure and initial adoption strategy on warning propagation and evacuation decision-making.

■ WB25

CC- Room 401

Revenue Management, Pricing III

Contributed Session

Chair: Ozden Engin Cakici, American University, NW, Washington, DC, 20016, United States

1 - Distribution Free Algorithms for Network Revenue Management

Jonathan Z. Amar, Massachusetts Institute of Technology, Cambridge, MA, United States, amarj@mit.edu, Nikolaos Trichakis

We consider a canonical network revenue management model (NRM) in which a decision maker offers multiple products, which consume capacitated resources. We focus on environments where demand is highly uncertain, and the decision maker needs to make sales decisions in an online fashion. We provide a distribution-free online algorithm for NRM and analyze its performance and establish that the proposed algorithm is asymptotically optimal, by achieving the best possible competitive ratio. By analyzing special relevant network structures, we show how to tune our algorithm in an intuitive way. Computational experiments demonstrate the proposed algorithm to outperform existing methods.

2 - Price Markdowns to Induce Customers to Opt Out of Free Returns

Sajjad Najafi, Ross School of Business, University of Michigan, Ann arbor, MI, United States, snajafi@umich.edu, Izak Duenyas

We study a newly emerging product return policy in the retail e-commerce industry. Alongside the conventional free return option, consumers are offered an additional return alternative called opt-out of free return (FO). If consumers forego free return and pick FO, the firm offers them a price markdown, and they can still return the product during the grace period, but they will have to pay a fixed penalty and a variable penalty proportional to the product’s purchase price. We model this return policy with the aim of deriving managerial insights on when offering FO would be beneficial to firms, and if they offer it, how the firm can set the optimal markdown level.

3 - Dynamic Learning and Pricing with Time-inconsistent Customer Behavior

Belleh Fontem, Assistant Professor, University of Massachusetts Lowell, Lowell, MA, United States, Canan G. Corlu

We study a learning and pricing problem for an online seller who begins a sequence of transactions with a customer despite possessing zero information on the customer’s true valuation for an item that the seller peddles. To complicate matters, the customer’s purchasing decision criterion is modulated by a Markov process with two disparate states that are hidden from the seller. The seller’s goal is to price the item in such a way as to efficiently elicit the buyer’s true valuation, while at the same time maximizing discounted expected revenue. We design a recursive filtering pricing algorithm, and using ideas from martingale theory, prove that it eventually elicits the customer’s valuation.

4 - Cross Channel Fulfillment in Omni Channel Network

Ting Luo, California State University Fullerton, Fullerton, CA, United States

Omni-channel retailing creates seamless shopping experience for consumers and lucrative sales opportunities for retailers. But how to price and fulfill the order is always not an easy decision for the retailer under dynamic environment, especially with a network of brick-and-mortar stores. Using a choice model for consumer channel, we frame the retailer’s problem as an MDP, with real time decisions of pricing and cross-fulfillment. We find we can use cross-fulfillment to replace dynamic pricing decision. We also find an optimal strategy to utilize inventory resource on a network .

5 - Optimal Pricing in Markets with Non-Convex Costs

Navid Azizan, California Institute of Technology, Pasadena, CA, United States, Yu Su, Krishnamurthy Dvijotham, Adam Wierman

We consider a market (such as an electricity market) run by an operator, who seeks to satisfy a given consumer demand by purchasing it from a group of suppliers with nonconvex cost functions. The operator knows the cost functions and announces a price function for each supplier. Each supplier then makes an individual decision about how much to produce. We propose a new pricing scheme, which is applicable to general nonconvex costs, and allows using general parametric price functions. Our scheme allows finding prices that are economically more efficient and less discriminatory. We supplement the proposed method with a polytime approximation algorithm for finding the optimal quantities and parameters.

6 - Coordinating Procurement and Distribution Decisions of Brokers

Ozden Engin Cakici, Assistant Professor, American University, Washington, DC, United States, ozdengin@gmail.com, Itir Z. Karaesmen

Bidding decisions to procure goods in B2B markets are made under uncertainty and resemble pricing decisions to sell goods in B2C markets. We develop and analyze analytical models to determine the optimal bid values for a broker in the first stage and the optimal shipping decision in the second stage.

■ WB26

CC- Room 4C-1

Joint Session Serv Sci/Practice Curated: Machine Learning in Service Science

Joint Session

Chair: Xinying Hao, University of Texas, Austin, TX, 78731, United States

1 - Evaluation of Multiple Machine Learning Methods on Prediction of Users' Rate Based on Yelp Challenge Data Set

Aidin Tamhidi, UCLA, Los Angeles, CA, United States, aidintamhidi@ucla.edu, Rio Sonoyama

We aimed to predict the star rating that a Yelp user would probably assign to a business such as a Restaurant, a Hair salon, etc. which they have never met. The dataset which contains observations from users' rating to the businesses and their features is provided by the Yelp Dataset Challenge. Through dividing it into two parts, train dataset and validation data set, we fit models for this multi-class classification task and evaluate each of them based on their prediction accuracy on validation data set. Eventually, we compared models according to their results such as Root Mean Squared Error (RSME) and other evaluation criteria to suggest the best model for the prediction.

2 - A Deep Learning Based Approach for Consumer Complaint Analysis

Xiaoguang Tian, Purdue University Fort Wayne, Fort Wayne, IN, United States, Wen Fu

Complaint analysis allows firms to learn in a continuous manner to adapt their products and services to customer preferences. However, analyzing consumer complaints confronts several big data challenges: volume, velocity, variety, veracity, efficiency, and effectiveness. This study proposes a comprehensive customer-oriented model to tackle difficult tasks. The automated text mining and machine learning process could help firms respond quickly to demanding customers and support an enterprise level textual contents analysis.

3 - Optimizing Email Marketing Through Deep Reinforcement Learning.

Senne Van Steelandt, University of Tennessee, Knoxville, TN, United States, svanstee@vols.utk.edu, Michel Ballings, Dirk Van den Poel

A long-standing goal in Marketing Analytics is to devise an algorithm that learns superhuman proficiency in selecting the next best direct marketing action. It has long been considered an intractable problem owing to its massive search space, and the stochastic and delayed nature of action evaluation. Using data provided to us by a US online retailer, we introduce a deep RL framework to efficiently learn next best email actions. After pre-training the model on historical data, we employ it in a real-life experiment, where results show it outcompetes human-guided decision making.

4 - A Study on Big Data Business Analytics System, Value Creation, and Triple-A in Firm's Supply Chain Management

Peter Wui, Professor, University of Arkansas-Pine Bluff, Pine Blufff, AR, United States, wuiy@uapb.edu

The purpose of this paper was to identify the value creation of the BDBA system and to understand how such a value creation affects the Triple-A of SCM. In order to accomplish the purpose, the literature was reviewed and a research model was devised with the two main hypothesis. The hypothesis on whether a BDBA system affects its value creation was adopted. The hypothesis that the BABD's created value affects the Triple-A of SCM was also adopted in a high level significance. The created value of the BDBA system has a positive significant influence on the agility, adaptability, and alignment of the SCM with the highest impacts on agility performance.

5 - Emoji as a New Targeting Language: A Multi-modal Emoji Mining Approach

Xinying Hao, University of Arizona, Tucson, AZ, United States, xyhao@email.arizona.edu, Vijay Mahajan

Emoji targeting has made its debut in marketing practice. In this paper, we develop a multi-modal emoji-mining approach and examine the incremental effect of using emojis in targeted messages. To overcome the technical challenge that no emoji-mining approach is currently available in the marketing literature, we leverage state-of-the-art deep learning tools by training on a large Twitter dataset. We develop a multi-modal approach that combines both the visual and textual features, and we fuse the information from both modalities to decode the emoji representation. We validate our approach by investigating the incremental effect of emoji use on targeting outcomes (e.g. CTR) via experiments.

6 - A Study on Big Data Business Analytics System, Value Creation, and Triple-A in Firm's Supply Chain Management

Sungho Kim

The purpose of this paper was to identify the value creation of the BDBA system and to understand how such a value creation affects the Triple-A of SCM. In order to accomplish the purpose, the literature was reviewed and a research model was devised with the two main hypothesis. The hypothesis on whether a BDBA system affects its value creation was adopted. The hypothesis that the BABD's created value affects the Triple-A of SCM was also adopted in a high level significance. The created value of the BDBA system has a positive significant influence on the agility, adaptability, and alignment of the SCM with the highest impacts on agility performance.

■ WB27

CC- Room 4C-2

Food Waste in the Grocery Retail Industry

Sponsored: Service Science

Sponsored Session

Chair: Astashkina Ekaterina

1 - Optimal Issuing Policy for Perishables with Deteriorating Quality

Jae Hyuck Park, Stanford University, Stanford, CA, 94305, United States, jaehyuck@stanford.edu, Erica Plambeck, Dan Andrei Iancu

We consider a retailer who sells a perishable product whose quality deteriorates over time. The retailer maximizes the long-run average customer welfare by jointly deciding whether to issue the oldest or newest stock first to consumers and when to remove unsold items from the shelf. As the deterioration rate and the salvage value increase, it is optimal to issue the newest available item first and salvage items earlier. We show that the retailer can simultaneously improve profitability and customer welfare while reducing food waste by converting unsold inventory into by-product.

2 - Buy-one-Get-one-Free: Impact on Profit and Waste

Dorothee Honhon, Associate Professor of Operations Management, University of Texas at Dallas, Richardson, TX, 75080, United States, dorothee.honhon@utdallas.edu, Qi Wu

We study how Buy-One-Get-One-Free (BOGOF) promotions for perishable items affect a retailer's profits and the amount of waste, both at the store and the consumer levels. We compare the traditional BOGOF campaign in which the consumer immediately gets two items for the price of one to a promotion where the consumer receives a coupon for a free item on her next store visit. We show that in some cases, choosing the proper promotion strategy can lead to more profits and less waste.

3 - Reducing Food Waste at Grocery Stores Through Omni-channel Retailing

Chokdee Siawsolit, Drucker School at Claremont Graduate University, 839 Endicott Drive, Claremont, CA, 91711, United States, csiawsolit@yahoo.com, Gary M. Gaukler

The USDA estimates that roughly 10% of our food supplies are lost at the retail level, costing major national chains nearly 15% in revenue and 43 billion pounds of discarded food annually. To address this pressing matter, we develop an MDP-based inventory model to compare and contrast two strategies that an omni-channel grocery retailer can deploy to reduce food waste, including accepting online orders in advance and allowing backlog order placements on out-of-stock items.

■ WB28

CC- Room 4C-3

Enhancing Cyber-Physical Security and Resilience of Smart Grid

Sponsored: Service Science

Sponsored Session

Chair: Wei Sun, PhD, University of Central Florida, FL, United States

1 - Moderator

Wei Sun, University of Central Florida, Orlando, FL, 32816, United States, wei.sun@ucf.edu

This panel will host five talks on enhancing cyber-physical security and resilience of smart grid. First talk will introduce a generative adversarial network-based approach to defend smart grid against cyber data attacks. Second talk will discuss about how to enhance cyber-physical security using power electronic devices. Third talk will introduce how to recover from cyber-physical attacks, and fourth talk will be focused on improving smart grid resilience using simulation-based optimization approach. Last talk will cover state-of-the-art research and testbed on cyber-physical security of smart grids.

2 - Cyber-physical Security of Power-electronics Enabled Power Systems

Yunhe Hou, University of Hong Kong, Hong Kong, yhhou@eee.hku.hk

3 - A Simulation-based Optimization Approach to Improve Power Grids Weather Resilience

Jie Xu, George Mason University, Fairfax, VA, 22030, United States, jxu13@gmu.edu

4 - Cyber-physical Attacks Recovery for Self-healing Smart Grids

Wei Sun, Assistant Professor, University of Central Florida, Orlando, FL, 32816, United States, wei.sun@ucf.edu

5 - Measuring and Enabling Cyber-Physical Resiliency of the Electric Grid

Anurag Srivastava, Washington State University, EME 102 Spokane St, Pullman, WA, 99164, United States

6 - Protecting CPS/IoT from End to End

Xinwen Fu, University of Central Florida, Orlando, FL, United States

■ WB29

CC- Room 4C-4

Fair Division Session

Sponsored: Auction and Market Design

Sponsored Session

Chair: Shai Vardi, Purdue University, Caltech, West Lafayette, IN, 91125, United States

1 - Communication Complexity of Cake Cutting

Simina Branzei, Noah Nissan, Purdue University, West Lafayette, IN

We study classic cake-cutting problems, but in discrete models rather than using infinite-precision real values, specifically, focusing on their communication complexity. Using general discrete simulations of classical infinite-precision protocols (Robertson-Webb and moving-knife), we roughly partition the various fair-allocation problems into 3 classes: “easy” (constant number of rounds of logarithmic many bits), “medium” (poly-logarithmic total communication), and “hard”. Our main technical result concerns two of the “medium” problems (perfect allocation for 2 players and equitable allocation for any number of players) which we prove are not in the “easy” class. Our main open problem is to separate the “hard” from the “medium” classes.

2- An Improved Approximation Algorithm for Maximin Shares

Jugal Garg, Univ of Illinois At Urbana Champaign, Urbana, IL, United States, Setareh Taki

We study the problem of fair allocation of m indivisible items among n agents with additive valuations using the popular notion of maximin share as our measure of fairness. The maximin share (MMS) of an agent is the maximum she can guarantee herself if she is allowed to choose a partition of items into n bundles, with the condition that all other agents get to choose a bundle before her. An MMS allocation provides each agent a bundle worth at least her maximin share. While it is known that such an allocation need not exist, a 3/4 MMS allocation always exists in which each agent receives a bundle worth at least 3/4 times her maximin share. We present a strongly polynomial algorithm that obtains a 3/4 MMS allocation.

3 - How to Make Envy Vanish Over Time

Gerdus Benade, Carnegie Mellon University, Pittsburgh, PA, United States, Ariel Procaccia, Aleksandr M. Kazachkov, Christos-Alexandros Psomas

We study the dynamic fair division of indivisible goods. Suppose at every time step an item arrives online and must be allocated to an agent, and agents have heterogeneous values for the items. Our goal is to design allocation algorithms that minimize envy, defined as the maximum difference between any agent’s overall value another agent’s allocation and his own. We design asymptotically optimal allocation algorithms with vanishing envy.

4 - Fair Bandwidth Allocation

Shai Vardi, West Lafayette, IN, 47906, United States, Benjamin Moseley

We study the fair allocation of bandwidth to users in a geometric space, using a new scheduling model.

■ WB30

CC- Room 6A

Decision Support Systems I

Contributed Session

Chair: Rodrigo Ulloa, Arizona State University, Tempe, AZ, 85281, United States

1 - An Effective Marketing Promotions Policy to Maximize Profits

Srikanth Vadde, Director of Data Science, Kaizen Analytix, Atlanta, GA, United States, srikanth.vadde@kaizenanalytix.com, Tom Tang, Anand Srinivasan

Marketing teams often face the challenge of designing an effective promotion policy to maximize return-on-investment without exceeding the allocated budget. Firms often fall short of designing effective promotion programs due to the inherent complexity of understanding their customers willingness-to-pay a price. This work presents a framework to design an effective promotions program considering customer willingness-to-pay using optimization. A case study is presented to demonstrate the approach and its effectiveness.

2 - Intelligent Automation - Automobile Insurance Fraud Detection

Xi Liu, The University of Manchester, Manchester, United Kingdom, Kennedys Law LLP, Manchester, United Kingdom

In this presentation, we will introduce a transparent intelligent automation system which can provide a decision on detecting fraudulent claims by considering complex experienced-based rules and by analysing & managing a large amount of insurance data. In this system, a rule-based inference methodology is developed by pre-defining optimal relationships between inputs and outputs through probabilistic inference and prediction. The whole system can be fine-tuned by combining expert knowledge and insurance data. This intelligent automated decision-making system not only reduces underwriters decision cycle time but also improves the quality of decision making.

3 - A Prediction-optimization Framework for Site-wide Process Optimization

Xiang (Claire) Ma, Senior Data Scientist & Managing Consultant, IBM Canada, Vancouver, BC, Canada, claire.ma1@ibm.com, Dharmashankar Subramanian, Pavankumar Murali, Nianjun Zhou, Giovane Cesar Da Silva, Raju Pavuluri, Jayant Kalagnanam

A multi-plant production site is a complex network of process plants and storage tanks with continuous flows of materials and products. Optimizing production and managing inventories in real time have been challenging for operations managers as there are various local breakdowns at different plants and shifting economic objectives. To help improve the production planning decision, we present a novel solution based on the use of machine learning to learn process relationships from sensor data and converting the process network into a prediction-optimization framework using segmented linear models and couple them with mixed-integer linear programming for site-wide production optimization.

4 - A Flexible Packing Optimization Approach to Improve Product Quality and Worker Training

Roshanak Akram, Graduate Research Assistant, The University of Tennessee, Knoxville, Knoxville, TN, United States, roshanak@utk.edu, Rapinder Sawhney, Ninad Pradhan

Product life cycles in industries using flexible packing materials have reduced. Ad-hoc packing strategies result in loss of product and package quality. The packing strategy must be dynamic, standardized, and must integrate worker training to address these challenges. This paper presents an optimization-based strategy rooted in Industry 4.0 goals of ``quality” and ``worker well-being”. The proposed intelligent automation model allows packing facilities to be responsive to product innovations and resultant packaging changes. The integrated SOP generation and worker training framework has direct benefit to workers as well as managers.

5 - Integrated Stochastic Planning Platform for Small Agricultural Growers with an Application to Arizona and New Mexico

Rodrigo Ulloa, Arizona State University, Tempe, AZ, United States, rulloa1@asu.edu, Hector Flores, J. Rene Villalobos

We propose a decision-making support platform for small farmers in their process of planning the next season. We consider farmers location, resources availability and operational costs; also random parameters such as weather conditions and products prices. We developed a tactical stochastic planning optimization model, which outputs are crop selection, planting/harvesting schedules, resources allocation, and logistic decisions as well. We added a machine learning component to the algorithm to get insights from the information of intermediate solving stages. Furthermore, we present an application of this planning tool to local growers in Arizona and New Mexico.

■ WB31

CC- Room 6B

Soft Skills and Client Relations in the Handbook of Military and Defense Operations Research

Sponsored: Military and Security

Sponsored Session

Chair: Natalie M Scala, Towson University, Towson, MD, 21252, United States

Chair: James P. Howard, Johns Hopkins Applied Physics Laboratory, Johns Hopkins Applied Physics Laboratory, Columbia, MD, 21045, United States

1 - Why Won't They Use My Model? Difficulties in Implementing Optimal Scheduling Models

Walt DeGrange, CANA Advisors, Chapel Hill, NC, 27517, United States, wdegrange@canallc.com

What if someone were to furnish you with a Ferrari and pay for all the fuel, tires, insurance, and maintenance. How would you drive the car? Surprisingly this is what happens in the United States military when the services provide forces to operational commanders. The Replenishment at Sea Planning (RASP) tool schedules supply ships using an optimization that solves the traveling salesman problem with moving cities (customer ships). Even though the tool reduced hours of planning to a few minutes, it took years for implementation. This brief covers why it took so long, why change is so hard, and what we did to improve the implementation process.

2 - MS Excel - The Multitool of Analysis

Joseph Lindquist, Program Director, US Military Academy, West Point, NY, United States, joseph.lindquist@westpoint.edu

While specialized tools exist to conduct most operations research analysis, a common tool across the entire DoD Enterprise, available on virtually every computer system no matter where an analyst finds themselves is a spreadsheet. This chapter will demonstrate how this common analytical tool can be used to conduct analysis on the following classes of problems: Statistical analysis (to include summary statistics, regression, data exploration, and visualization). A subset of linear and non-linear optimization problems Simulation for use in queuing models (to include creation of empirical distribution functions).

3 - From Bogsat to Turboteam: Collaboration for National Security Teams in the Age of Analytics

Freeman Marvin, Executive Principal, Innovative Decisions, Inc., Broad Run, VA, 20137, United States, ffmarvin@innovativedecisions.com

Recent experience with a range of national security and public safety team meetings has shown that there are new ways to combine process facilitation, analytic techniques, and computer software right in the meeting room to improve the quality of problem solving and decision making. The Analytic Collaboration approach builds on a foundation of process facilitation and structured analytic techniques with Simple Analytic Models (SAMs). This chapter describes the Analytic Collaboration process and how six national security and public safety teams used SAMs to improve meeting effectiveness. The chapter illustrates this approach using three common team tasks: deciding, diagnosing, and designing.

■ WB32

CC- Room 6C

Spatial Analysis

Contributed Session

Chair: Sepideh Yazdekhasti, Xylem Inc

1 - Growth Process Modeling of Carbon Nanotubes: A Hierarchical Physical-statistical Model

Mengqi Fan, Tsinghua University, Beijing, China, fmq15@mails.tsinghua.edu.cn

In scaling-up Carbon Nanotubes (CNTs) array manufacturing, the uniformity of CNTs' height, or flatness of array needs to be properly controlled. This research work aims to model the growth process based on a hierarchical physical-statistical model. This model consists of two major components: morphology and local variability. The morphology component represents the overall trend characterized by the physical model. The area-specific variability is less understood in nanophysics due to complex spatial correlation, characterized by the Kriging model. Simulation and validation are provided to verify the performance of the proposed model.

2 - Prediction of Water Main Failures with the Spatial Clustering of Breaks

Thomas Ying-Jeh Chen, University of Michigan, Ann Arbor, MI, United States, tyjchen@umich.edu

Due to limited budgets and an aging system, infrastructure managers have increasingly sought cost-effective means to evaluate asset condition. A spatial clustering of pipe breaks fits well into a wider asset management framework. The information about spatial clusters identified using historical breaks, if and where they exist, can potentially improve predictions on the location of future breaks. In this research, we present three algorithms for scanning and clustering pipe break data and demonstrate its application on a real pipeline network. We also explore whether the use of spatial clusters as an explanatory variable can improve the accuracy of pipe break machine learning models.

3 - Estimation of Monetary Damages in a Water Network During Pipe Failure

Sepideh Yazdekhasti, Xylem Inc, Columbia, MD, United States, Karl Ivan San Luis, Amin Ganjidoost, Craig Daly

Monetary estimation of damages arising from pipe failures is an evolution from a factor based approach which aids in prioritizing million dollar capital improvement planning projects for water utilities. An innovative, monetized consequence of failure approach is presented where it follows a three-step process of data gathering, quantifying the customers affected and quantifying the monetary impact for each affected customer. The results lead to a continuous scale distribution which is closer to an exponential distribution rather than a centrally weighted distribution. This approach forms a solid foundation in optimizing the best return on investment for capital projects.

■ WB33

CC- Room 602

Reinforcement Learning for Scheduling

Contributed Session

Chair: Mohammad Dehghanimohammadabadi, Northeastern University, Boston, MA, 02115, United States

1 - Multipriority Patient Scheduling in the Emergency Room Using a Reinforcement Learning Approach

Seonghyeon Park, Yonsei University, Seoul, Korea, Republic of, s.park10@yonsei.ac.kr, Young Hoon Lee

To establish a effective scheduling, it is important to know the operation sequence of jobs in advance. However, the operation sequence of patients in the emergency room appears in a stochastic pattern. This leads to the unique problem that represented by a dynamically changing graph in which the next process is determined stochastically. We propose a patient scheduling model that minimizes the tardiness of multi-priority patients in the emergency room using a reinforcement learning approach. The proposed model is shown to yield an improved result than existing ones in a less computational effort.

2 - A Reinforcement Learning Based Algorithm to Schedule Multi-category Patients at a Multi-facility Hospital

Varun Jain, Tiger Analytics, Chennai, India, varunjain.vj.5@gmail.com, Usha Mohan

One of the key operational decisions faced by hospitals is the choice of the patient category to serve for a test. We include health check-up patient category who need to be served for a sequence of tests as against the other categories of patients (Outpatient and Emergency Patients) who usually are served at one test. We use Markov Decision Process (MDP) to capture the system dynamics with the objective of maximizing net revenue. We factor the MDP formulation to a decentralized MDP, and we propose a reinforcement learning based heuristic to solve it. We show the efficiency of the proposed heuristic through numerical experiments.

3 - Robotic Cell Scheduling with a Reinforcement Learning Approach

Hyun-Jung Kim, Korea Advanced Institute of Science and Technology, Daejeon, Korea, Republic of, kim.hj@skku.edu, Jun-Ho Lee

A robotic cell scheduling problem is addressed with a reinforcement learning approach. There are two part types processed on a different set of machines, and a material handling robot transports each part between machines. Processing times on machines have a variation, and the objective is to find an efficient robot task sequence in order to minimize makespan. The experimental result shows that the proposed algorithm performs better than a dispatching rule.

4 - Reinforcement Learning for the Vehicle Routing Problem with Time Windows

Yanfei Huang, Eindhoven University of Technology, Eindhoven, Netherlands, y.huang1@tue.nl, Virginie Lurkin, Tom Van Woensel

Following the development of computer technology and digitization, machine learning algorithms outperform classical approaches in solving various models. In this paper, the vehicle routing problem with time windows is formulated as a Markov Decision Process and a Reinforcement Learning model is developed. Unlike other kinds of heuristic methods, reinforcement learning model learns from the data generated during the training so that no heuristic rules need to build up.

5 - Online Operation of Electric Automated Taxi Fleets

Xindi Tang, Tsinghua University, Beijing, China, Meng Li, Xi Lin, Fang He

It is foreseeable that electric automated taxis will play an important role in future transportation systems for serving diverse travel demands. In this study, we propose a two-stage methodological framework to solve the online operation problem of electric automated taxi fleets with combinatorial optimization <and> reinforcement learning. A centralized control system dynamically manages taxis to be assigned to serve demands, dispatched to eliminate supply-demand imbalance <and> forced to charging stations to get refueled. The experiments show that our method outperforms the myopic model in realistic cost where the taxis can be dispatched to the zone with peak-hour demands in advance.

■ WB35

CC- Room 604

Mixed Integer Optimization

Contributed Session

Chair: Azadeh Ahkamiraad, SUNY at Binghamton, Binghamton, NY, 13905, United States

1 - Shorter Automatic Extremality Proofs for Cut-generating Functions

Yuan Zhou, University of Kentucky, Lexington, KY, United States, yuan.zhou@uky.edu

We present a new implementation of our automatic theorem proving technique in the domain of cut-generating functions for integer programs. The new implementation uses a more powerful representation of proof cells as half-open basic semialgebraic sets. It employs strategies that lead to larger proof cells and thus shorter proofs. We use our implementation to automatically prove cutting-plane theorems from the literature.

2 - Strong Valid Inequalities for the Survivable Multi-Module Network Design Problem

Haochen Luo, Texas A&M University, College Station, TX, 77843-3131, United States, Kiavash Kianfar

Capacitated survivable network design (SND), i.e., designing a network that can survive edge failures with minimum flow-routing plus capacity-installation cost, is a fundamental problem in network science and its applications. We study a highly applicable form of SND, referred to as the multi-module SND (MM-SND), in which transmission capacities on edges can be sum of integer multiples of differently sized capacity modules. We formulate MM-SND as a mixed integer program (MIP) and derive several classes of valid inequalities for this MIP, and show that the valid inequalities previously developed in the literature for the single-module SND are special cases of our inequalities. Furthermore, we show that our valid inequalities are facet-defining for MM-SND in many cases. Our computational results, using a heuristic separation algorithm, show that these inequalities are very effective in solving MM-SND.

3 - Matrices with Lexicographically-ordered Rows

Gustavo Angulo, Pontificia Universidad Católica de Chile, Santiago, Chile, gangulo@ing.puc.cl

The lexicographic order can be used to force a collection of decision vectors to be all different, i.e., to take on different values in some coordinates. We consider the set of fixed-size matrices with bounded integer entries and rows in lexicographic order. We present a dynamic program to optimize a linear function over this set, from which we obtain a compact extended formulation for its convex hull.

4 - Team Formation on Social Networks

Nihal Berktas, Bilkent University, Ankara, Turkey, nihal.berktas@bilkent.edu.tr, Hande Yaman

We study the Team Formation Problem (TFP) in which the quality and cost of communication is taken into account using the proximity of the potential members in a social network. Given a set of required skills, TFP aims to construct a capable team that can communicate effectively. To solve larger sizes, we propose a novel branch and bound approach: we formulate the problem as a constrained quadratic set covering problem, use the reformulation-linearization technique and relaxation to be able to decompose it into a series of linear set covering problems and impose the relaxed constraints through branching. The algorithm is capable of solving large sizes that are intractable for the solver.

5 - Generating Effective Constraints for Bilevel Mixed Integer Linear Programming

Wei Wang, University of Pittsburgh, Pittsburgh, PA, United States, w.wei@pitt.edu, Bo Zeng

Generally, bilevel mixed integer linear programming (BMILP) problems are difficult to solve and the traditional high point relaxation is often weak. In this study, we generate strong constraints, which can be adopted in a branch-and-cut frame work, to remove bilevel infeasible solutions. Computational experiments on testing problems will be presented to demonstrate the effectiveness of our constraints.

6 - Time Based Electric Demand Response for Smart Homes with Electric Vehicles and Renewables

Azadeh Ahkamiraad, SUN Y. at Binghamton, Binghamton, NY, United States, Arefeh Mohammadi

It is expected that micro-grid solutions will provide fundamental changes in energy consumption behavior. While the tendency toward intermittent energy storage systems is growing considerably, this study introduces an intelligent home demand-side model for households empowered by electric vehicles, storage facilities, and renewables as local resources. With the objective of minimizing the energy cost, a mixed-integer linear program is proposed to maximize the use of renewables while scheduling the operation of home appliances under varied pricing strategies. The model is carried out in Lingo and simulation results under varied scenarios demonstrate the effectiveness of the technique.

■ WB36

CC- Room 605

Stochastic Nonlinear Mixed-Integer Problems: Conic Programming Approaches

Sponsored: Optimization/Optimization Under Uncertainty

Sponsored Session

Chair: Janiele Custodio, George Washington University, DC, United States

1 - A Two-stage Distributionally Robust Chance-constrained Model for Humanitarian Relief Network Design

Ran Ji, Assistant Professor, George Mason University, Fairfax, VA, 22030, United States, rji2@gmu.edu, Zhenlong Jiang

We study a distributionally robust chance-constrained optimization problem for pre-disaster relief network that determines facility locations and capacities, their inventory level and distribution of relief supplies under uncertainty of post-disaster demands and facility conditions. By leveraging Bonferroni and worst-case CVaR approximation, we develop conic representable formulations. Computational studies on real-world applications are conducted to demonstrate the performance of proposed models.

2 - Conic Reformulations of Queuing Stochastic Location-Allocation Models with Decision-Dependend Uncertainty

Janiele Custodio, George Washington University, Washington, DC, 20011, United States, janiele@gwu.edu, Miguel Lejeune

This research presents a new class of stochastic location allocation optimization models. The uncertainty is modeled using queuing theory and the parameters of the system are determined endogenously. We explicitly consider the minimization of the response time of a drone network delivery system. We present an equivalent convex reformulation of the model based on conic programming. We present an application to a discrete facility location model and also to a continuous facility location on the plane model.

3 - On Risk-averse Optimization in Discrete Systems

Pavlo A. Krokhmal, Professor, University of Arizona, Department of Systems & Industrial Engineerin, 1127 E. James E. Rogers Way, Tucson, AZ, 85721, United States

In this talk we discuss risk-averse stochastic optimization in discrete systems, such networks or graphs. In particular, we consider identification of minimum-risk structures in stochastic networks. A family of certainty equivalent coherent/convex measures of risk is employed, resulting in mixed-integer conic programming with non-symmetric cones. Among applications, we consider determining the systemic risk of a networked system.

4 - Approaching Probability Computation of Implicit Sets by Algebraic Means

Ruediger Schultz, University of Duisburg-Essen, Department of Mathematics, Thea-Leymann-Str. 9, Essen, D-45127, Germany, ruediger.schultz@uni-due.de

In stochastic programming, computing probabilities of implicitly given sets has been a research focus since the advent of chance constraints. Recently, this development received another boost by capacity optimization under uncertainty in various industrial endeavours. In the talk we discuss steady state equations for gas flow arising from Kirchhoff's Laws. We arrive at a system of multivariate polynomials of order two. This system is easy to handle for gas networks with at most one cycle. If there are two or more cycles pairwise sharing edges the theory of ideals offers reduction techniques allowing for model streamlining and parametric solution of the system of polynomial equations.

■ WB37

CC- Room 606

Robust Optimization of Machine Learning Models

Sponsored: Optimization/Optimization Under Uncertainty

Sponsored Session

Chair: Dimitri Papadimitriou, Brussels, 1190, Belgium

1 - The Stochastic Multigradient Algorithm and its Application to Supervised Machine Learning

Suyun Liu, Lehigh University, Bethlehem, PA, United States, Luis Nunes Vicente

We study the stochastic multi-gradient (SMG) method, seen as a natural extension of the classical stochastic gradient method from single to multi-objective optimization (MOO). We establish the convergence rates to compute a point in the Pareto front. The analysis handles the bias in the multi-gradient and the unknown a priori weights of the limit Pareto point. The SMG method is framed into a more general algorithm for the computation of the entire Pareto front. It can be applied to any stochastic MOO problem arising from supervised machine learning, and we report results for logistic binary classification where multiple objectives correspond to distinct-sources data groups.

2 - Integrating Benders' Decomposition and Piecewise Linear Approximation for Support Vector Machines

Yang-Chieh Ho, National Chiao-Tung University, Hsinchu, Taiwan, daisyhoho1105@gmail.com, Lo-Min Su, Sheng-I Chen

Machine learning optimization problem is to determine the parameters of a model to minimize errors based on the training data set. In the aspect of support vector machines, the problem is to obtain parameters of a linear system defined on feature space. The goal maximizes the distance between two parallel hyperplanes and minimizes classification errors. Such a model has been broadly utilized for data scientists to classify either labeled or unlabeled data. We integrate Benders decomposition and linear approximation for solving the primal problem of support vector machines. The results display computational performance and solution quality between the proposed method and existed algorithms.

3 - Physics-driven Regularization of Deep Neural Networks

Mohammad Amin Nabian, PhD Candidate, University of Illinois at Urbana-Champaign, Urbana, IL, United States, mnabia2@illinois.edu, Hadi Meidani

We introduce a physics-driven regularization method for training deep neural networks (DNNs) for engineering design and analysis. In particular, we focus on prediction of a physical system, for which in addition to training data, information on the governing laws is also available. These laws often appear in the form of differential equations derived from first principles. We propose a training approach that regularizes data-driven DNN models by penalizing divergence form the governing laws. As an application, we study metamodeling for aerodynamic design optimization of vehicles, where we demonstrate the superior accuracy of the proposed method compared to other common alternatives.

4 - Simple Estimators of Value of Data and Price of Data for Data-Driven Distributionally Robust Optimization

Jangho Park, Lawrence Berkeley National Laboratory, Berkeley, CA, 43210-1271, United States, janghopark@lbl.gov, David Love, Guzin Bayraksan

This paper investigates the value of additional data in a distributionally robust optimization (DRO). Such notions have been used in decision analysis and stochastic programming since the 50s. We extend it to the DRO setting. The change in the optimal value due to a specific additional observation of a scenario is called the value of data (VoD). The average change in the VoD is called the price of data (PoD). Additional optimization problems should be solved to calculate the VoD and estimate the PoD. This is computationally expensive. The paper provides estimators of VoD and PoD without solving any additional optimization problems and showcases how they can be used by decision makers to gain insight.

■ WB38

CC- Room 607

Optimization, Stochastic II

Contributed Session

Chair: Narges Sereshti, Dalhousie University, Halifax, NS, B3H 3M9, Canada

1 - Iterative Algorithms for Risk-averse Stochastic Combinatorial Optimization

Jaehyeon Ryu, Korea Advanced Institute of Science & Technology, Daejeon, Korea, Republic of, jhryu034@kaist.ac.kr, Sungsoo Park

We study risk-averse stochastic combinatorial optimization problems. The mean-standard deviation objective is defined to measure a risk that a linear cost function with independently distributed random coefficients becomes too large. Our problem is equivalent to a robust optimization problem with an ellipsoidal uncertainty set, and we approximate it by polyhedra. We solve the resulting approximate problem by solving some deterministic problems repeatedly. As a result, a (1+)-approximation algorithm, solving at most O(n^1.5/√) nominal problems is obtained. Moreover, we develop a practically fast convergent exact algorithm by adjusting and solving approximate problems iteratively.

2 - Risk-averse Bilevel Stochastic Linear Programs

Matthias Claus, University of Duisburg-Essen, Essen, Germany, matthias.claus@uni-due.de, Johanna Burtscheidt, Stephan Dempe

Two-stage stochastic programs and bilevel problems under stochastic uncertainty bear significant conceptual similarities. However, the step from the first to the latter mirrors the step from optimal values to optimal solutions and entails a loss of desirable analytical properties. The talk focuses on mean risk formulations of stochastic bilevel programs where the lower level problem is linear. Structural properties as continuous differentiability of the objective function are established. Furthermore, based on a growth condition, stability with respect to perturbations of the underlying measure is derived.

3 - Finite Time Analysis of Q Learning with Linear Function Approximation

Zaiwei Chen, Georgia Institute of Technology, Atlanta, GA, United States, Sheng Zhang, Thinh Doan, Siva Theja Maguluri, John-Paul Clarke

We consider in this paper the popular Q-learning method with linear function approximation for finding the optimal policy of a Markov decision problem. Our main contribution is, to provide a finite-time bound for the convergence rate of Q-learning with constant step sizes, without requiring the critical conditions on the i.i.d. sampling and impractical projection steps as often assumed in the existing literature. As a by-product, we provide sufficient conditions for the convergence of linear Q-learning with diminishing step sizes. We also performed comprehensive analysis, both theoretically and numerically, on the conditions needed for convergence.

4 - Integrating Benders Decomposition and Pure Cutting Plane Method for Solving Stochastic Integer Program

Yen-Ting Wu, National Chiao Tung University, Hsinchu, Taiwan, 0113304jason@gmail.com, Sheng-I Chen, Cheng-Yu Rao

Benders decomposition is a commonly-used approach for solving large-scale programs. The application in stochastic program is known as L-shaped method proposed for solving two-stage stochastic programs. However, it may not converge to optimal with integer recourse. This study focuses on a general case of two-stage stochastic programs, in which both stage problems are integer programs. We integrate the L-shaped method and Gomory cutting plane to obtain an approximate solution. A finite cutting plane method is proposed to the second-stage problem to obtain a lower bound of the recourse function. The computational result shows that the integrated method is capable to yield quality solutions.

5 - Investigating Aggregate vs Separate Service Level Constraints in the Stochastic Lot Sizing Problem

Narges Sereshti, HEC Montréal, Montréal, QC, B3H 3M9, Canada, Yossiri Adulyasak, Raf Jans

An efficient approach to deal with demand uncertainty in the multi-item lot-sizing problem is the stochastic programming models which generally consider the uncertainty in the forms of probabilistic distribution functions or probabilistic scenarios. These models are used to determine production plans which minimizes the expected total operating costs while ensuring that a predefined service level constraint for each product is satisfied. We extend and investigate these stochastic models of the multi-item lot-sizing to a more practical setting where multiple service levels can be used in conjunction across multiple products to ensure that the business requirements are satisfied on an aggregate level.

■ WB39

CC- Room 608

Neural Networks & Traffic Management

Contributed Session

Chair: Myungeun Eom, POSTECH, Pohang

1 - Unsupervised Anomaly Detection with Data-describing Deep Neural Network

Hyungrok Do, Korea University, Seoul, Korea, Republic of, hyungrok@korea.ac.kr, Seoung Bum Kim

Data description methods concern the characterization of a data set. A good description of data can be used to detect novel data or outliers. In this study, we propose a neural network-based data description algorithm, named neural data description (NDD). The proposed NDD algorithm simultaneously learns feature mapping from data and constructs compact hypersphere that encloses data points in the feature space. We demonstrate the effectiveness and applicability of the proposed algorithm through real-world data sets.

2 - Missing Data Imputation with Cycle-consistent Adversarial Networks

Hyungu Kahng, Korea University, Seoul, Korea, Republic of, hgkahng@korea.ac.kr, Seoung Bum Kim

We extend the recently proposed generative adversarial imputation networks (GAIN) framework for missing data imputation by introducing an additional regularization term to induce cycle consistency. The generator learns to predict the missing values and uses the predicted values to reconstruct the observed values. The discriminator attempts to determine which components are actually observed. Experiments on various datasets demonstrate that the proposed algorithm outperforms the GAIN and other imputation methods for various missing rates.

3 - Automatic Insect Count from Incomplete Scenes Using Convolutional Neural Networks

Jose Azucena, Ph. D. Student, University of Arkansas, Fayetteville, AR, United States, jch051@uark.edu, Haitao Liao

For geographical areas intended to be used for agricultural endeavors, an estimate of the size of existent insect populations can be of interest. A method capable of identifying and counting different species without manual or expert input is a valuable tool for population monitoring. This work proposes the use of Convolutional Neural Network models to learn from incomplete scenes. ResNet architecture is used to achieve robust estimations under variable specimen deformation. Simulated datasets of insect images are created, and the model is evaluated under various scenarios.

4 - Increasing Traffic Management Efficiency for Highway Authorities

Zainab Riaz, Assistant Professor, LUMS, Lahore, Pakistan, zainab.riaz@lums.edu.pk, Zeeshan Aziz

Decisions taken in early stages of Traffic Management planning have a huge influence on downstream implementation and in determination of road user impact. Given increasing demands and expectations from Road Network operators, decision-making will become more complex in years ahead. In this context, it is important to leverage existing data to drive efficiencies. In this paper, Traffic Management incursions and accident data sets were analysed with a view to drive insights and patterns from existing data sets, to ensure organisation is yielding benefits from data that is being collected and to demonstrate benefits that could be achieved by analysing the collected data.

5 - Adaptive Traffic Signal Control for Intersection Networks

Myungeun Eom, POSTECH, Pohang, Kyungbuk, Korea, Republic of, meeom@postech.ac.kr, Byung-In Kim

Adaptive traffic signal control is necessary to reduce traffic congestion at intersections. However, adaptive control for a network of intersections is challenging because the characteristics of the intersections and the network are unique and complicated, and traffic flows are highly stochastic. This talk proposes a simulation based optimization algorithm, which is applicable to various network types, to determine the optimized signal plan. The algorithm considers various objectives of the traffic signal control corresponding to principles of intelligent transportation systems.

6 - Examining the Spatiotemporal Trend of Left-turn Crashes with Multidimensional Panel Data At Intersections

Mengqing Xu, Southwest Jiaotong University, Chengdu, China, xumengqing1@163.com, Yingfei Fan

Based on 13-year multidimensional panel data (i.e., crash counts, geographical and spatial characteristics, traffic features, and economic variables) in Michigan, the paper adopts the support vector machine model to compare the spatiotemporal associations, including the independent-over-time random variation with the fixed spatial correlation, the fixed-over-time-space correlation, and the varying coefficient between time and space. Significantly explanatory variables are also identified.The results show that 1) three types of left-turn crashes show different spatiotemporal trends and 2) the spatiotemporal associations are correlated with the variation of economic variables.

■ WB40

CC- Room 609

Optimization, Integer Programming I

Contributed Session

Chair: Konstantin Pavlikov, University of Southern Denmark, Campusvej 55, Odense M, 5230, Denmark

1 - Learning-based Optimal Solution Prediction for Mixed Integer Programming

Jian-Ya Ding, Zhejiang Cainiao Supply Chain Management Co., Ltd., Hangzhou, China, jianya.djy@cainiao.com, Lei Shen, Peng Fei, Bing Wang, Yinghui Xu

Mixed Integer Programming (MIP) is a widely used modeling technique for combinatorial optimizations. In most applications, a similar MIP model is solved on a regular basis, maintaining the same form but differing in data. This allows the use of Machine Learning method to explore underlying information in MIP structures. In this paper, we present a solution predicting method to add initial cuts to the MIP model. Rather than treating each decision variable isolatedly, we view coefficients matrix in MIP as a graph and use graph embedding to analyze variable connections. Numerical evaluations show significant improvements in several different MIP problems, including two Cainiao online applications.

2 - Mixed-Integer Multi-Objective Optimization through Multiparametric Programming

Styliani Avraamidou, Texas A&M University, College Station, TX, United States, styliana@tamu.edu, Iosif Pappas, Burcu Beykal, Baris Burnak, Justin Katz, Metin Turkay, Efstratios Pistikopoulos

Optimization problems involving more than one objective function are referred to as Multi-Objective Optimization (MOO) problems. In this work, we present an algorithm for the exact explicit derivation of the Pareto front of mixed-integer linear MOO problems based on multi-parametric programming. The -constraint approach is used to transform the MOO problem into a single objective multi-parametric mixed-integer linear problem where the tunable suboptimality variables (resulting from the -constraints) are considered as parameters. The proposed approach is illustrated through a set of numerical examples and its capabilities are demonstrated in a computational study.

3 - A Multi-parameter Sensitivity Analysis of Linear Integer Program

C Y. (Chor-yiu) Sin, National Tsing Hua University, Hsinchu, Taiwan, cysin@mx.nthu.edu.tw

A stochastic programming with P states can well be formulated as a deterministic programming with P-1 probabilities. In this and the case with non-linearity in parameters, when one parameter changes the others may also change. Consequently the existing sensitivity analysis in the linear integer program may not be applicable, as it confines the attention to one-parameter change. This paper considers a special type of Lagrangian dual function which renders strong duality. Using this Lagrangian dual function, we first generalize the result in Shapiro (1977) to multi-parameter cases. Further, we show with synthetic data that our analyses save a lot of computer time in large-scale optimization.

4 - Weapon-target Assignment Problem: Exact and Approximate Solution Algorithms

Konstantin Pavlikov, University of Southern Denmark, Odense M, Denmark

The Weapon-Target Assignment (WTA) problem aims to assign a set of weapons to a number of targets, such that the expected value of survived targets is minimized. The WTA problem is a nonlinear combinatorial optimization problem known to be NP-hard. We employ several techniques to linearize the WTA problem, which makes the problem more tractable from computational point of view. Mixed integer linear reformulations of the WTA problem are solved using state of the art optimization software. Numerical experiments demonstrate that problem instances of size of up to 250 weapons and 500 targets can be solved to optimality and larger instances to suboptimality with small gaps within reasonable amount of time.

■ WB41

CC- Room 610

Joint Session OPT/Network/Practice Curated: Supply Chain and Inter-firm Networks

Sponsored: Optimization/Network Optimization

Sponsored Session

Chair: Hyunwoo Park, The Ohio State University, Columbus, OH, 43210, United States

1 - Structural Embeddedness and Efficiency of Warehouse Inventory Management: a Network Perspective

Kedong Chen, University of Minnesota, Minneapolis, MN, 55414, United States, chen3548@umn.edu, Hung-Chung Su, William Li, Kevin W. Linderman

Inventory efficiency is a key performance indicator for warehouse managers when companies increasingly rely on intricate networks of warehouses to satisfy customer demands. Facing demand and product variabilities, How can warehouse managers take advantage of the network structure to better handle variabilities and improve inventory efficiency? The concept of structural embeddedness captures the focal warehouse's connections with other warehouses in the network. Through a two-stage least-square fixed-effects model on a panel dataset, we examine the effects of structural embeddedness and how it interacts with product and demand variabilities to affect inventory efficiency of a warehouse.

2 - Modeling Uncertain and Dynamic Interdependencies of Infrastructure Systems with Stochastic Block Model

Jin-Zhu Yu, Vanderbilt University, Nashville, TN, United States, yujinzhu88@gmail.com, Hiba Baroud

Modeling the resilience of interdependent critical infrastructure (ICI) requires a careful assessment of interdependencies as these systems become interconnected. The interdependency across ICIs are often subject to uncertainty due to lack of data. This paper develops an approach to modeling the interdependency of ICIs with probabilistic graphical models. Specifically, the approach estimates the probability of links between individual systems considered as blocks in the stochastic block model. The proposed model uses several nodal attributes as predictors. The proposed approach is illustrated with a case study of the interdependent water and power networks in Shelby County, Tennessee.

3 - The Role of Structural Characteristics of Entities in Explaining Firm Performance in Inter-firm Networks

Gyusuk Lee, Michigan State University, East Lansing, MI, United States, leegyus1@broad.msu.edu, Srinivas Talluri

The research objective of this study is to investigate the impact of supply network structures on performance of different supply chain entities in various settings. The structural characteristics of supply network and its entities will be modeled through social network analysis. The role of different supply network structures and structural positions of supply chain participants in explaining firm performance will be empirically tested utilizing panel network data.

4 - How Do Technological Characteristics of a Firm's Supply Network Drive its Innovativeness?

Shubhobrata Palit, Student, Georgia Institute of Technology, 8 00 West Peachtree NW, Atlanta, GA, 30308, United States, Manpreet Singh Hora, Soumen Ghosh

We examine how the technology characteristics of a firm's supply network drive its innovation capability. Using the innovation and the supply chain relationship data, we find empirical support for hypotheses linking technology characteristics of a firm's supply network and the firm's innovation capability. This study has important managerial implications for sourcing and innovation strategy.

■ WB42

CC- Room 611

Network Optimization Models and Applications

Sponsored: Optimization/Network Optimization

Sponsored Session

Chair: Navid Matin Moghaddam, Tempe, AZ, 85281, United States

1 - Two-stage Robust Minimum Cost Flow under Demand Uncertainty

Sabrina Schmitz, RWTH Aachen University, Aachen, Germany, Christina Büsing, Arie M.C.A. Koster

In this talk, we introduce a minimum cost flow model where on the one hand demand and supply are subject to uncertainty and on the other hand flow values of a predetermined set of arcs have to be equal in all demand and supply realizations. The integration of these aspects is motivated by, for example, long-term contracts in logistics where the transportation volumes of subcontractors need to be determined before the number of shipments are known. In the case of a discrete set of scenarios, we derive structural results, study the problem's complexity, and analyze first algorithms.

2 - Cell-based Dynamic Evacuation Traffic Management under Risk and Resource Allocation Considerations

Vedat Bayram, Assistant Professor, TED University, Ankara, Turkey, vedat.bayram@tedu.edu.tr, Hande Yaman

In this study, an evacuation management problem based on cell transmission model (CTM) is presented. Although cell-based approach models the traffic phenomenon in the most realistic way, it can hardly handle realistic-size instances due to excessive memory and/or CPU time requirements. We transform the original road network to a cell network and the cell network to a time expanded network to efficiently solve realistic instances. We consider hazard values of road segments that change dynamically over time. We also study the optimal dynamic resource allocation strategies to enable efficient use of road capacities. We present methodologies to efficiently solve the problem.

3 - An Exact Bidirectional Pulse Algorithm for the Constrained Shortest Path Problem

Andres L. Medaglia, Universidad de los Andes, Cr 1 este #19 A. 40, Ingenieria Industrial, ML711, Bogota, 111711, Colombia, amedagli@uniandes.edu.co, Nicolás Cabrera, Leonardo Lozano, Daniel Duque

A constrained shortest path is a minimum-cost sequence of arcs on a directed network that satisfies knapsack-type constraints on the resource consumption over the arcs. We propose an exact method based on a recursive depth-first search procedure known as the pulse algorithm. One of the key novelties of the proposal lies in a bidirectional labeling strategy leveraged on parallelism. In addition, we developed a pulse-based heuristic that quickly finds near-optimal solutions and shows great potential for column generation schemes. We present computational experiments over large real-road networks with up to 6 million nodes and 15 million arcs.

4 - Large-Scale Network Design with Application to Carbon Capture and Storage

Navid Matin Moghaddam, Arizona State University, Tempe, AZ, 85281, United States, nmatinm@asu.edu, Jorge A. Sefair

We study a fixed charge network design problem with application to carbon capture and storage (CCS). Motivated by the emerging need of climate stabilization, CCS seeks to prevent carbon emissions from entering the atmosphere by capturing, compressing, and transporting CO2 from sources (e.g., oil refineries) to geologic reservoirs (e.g., depleted oil wells) for its long-term storage. To find the least-cost network of pipelines able to transport a target amount of CO2, we propose an optimization model and an exact decomposition algorithm that takes advantage of the optimal solution sparsity and the problem's cost structure. We illustrate the performance of our methods on a set of real instances.

■ WB43

CC- Room 612

Geometry and Optimization

Sponsored: Computing

Sponsored Session

Chair: John Gunnar Carlsson, University of Southern California, University of Southern California, Los Angeles, 90089, United States

1 - Coordinated Logistics with a Truck and A Drone

John Gunnar Carlsson, University of Southern California, Los Angeles, CA, 90089, United States

We determine the efficiency of a delivery system in which an unmanned aerial vehicle (UAV), or a fleet of UAVs, provides service to customers while making return trips to a truck that is itself moving. In other words, a UAV picks up a package from the truck (which continues on its route), and after delivering the package, the UAV returns to the truck to pick up the next package. We conclude that the improvement in efficiency due to introducing a UAV is proportional to the square root of the ratio of the speeds of the truck and the UAV.

2 - Data-driven Optimization Approach for Inventory Planning

Hoda Bidkhori, University of Pittsburgh, Dept of Industrial Engineering, Pittburgh, PA, 15206, United States, bidkhori@pitt.edu, Ke Ren, Max Shen

We present a data-driven continuous-review inventory problem for a warehouse facing unknown non-stationary demands. We learn and update the inventory policies using both historical and daily observed demand data. We present four approaches, where two are Bayesian-based approaches and the other two are lasso-based. The Bayesian-based algorithms integrate both the inventory parameters and observed demands to identify the optimal inventory policies, whereas the lasso-based algorithms use the consistency between demands. Finally, we discuss how practitioners should choose the best approach based on their product data environments.

■ WB44

CC- Room 613

Joint Session ICS/ENRE: Computational Advances in Spatial Conservation

Sponsored: Computing

Sponsored Session

Chair: Esra Buyuktahtakin Toy, New Jersey Institute of Technology, Newark, NJ, 07102, United States

1 - Optimizing Conservation Planning for Multiple Cohabiting Species

Hayri Onal, University of Illinois, Agr. & Consumer Economics, 305 Mumford Hall, Urbana, IL, 61801, United States, h-onal@illinois.edu, Yicheng Wang

We introduce a linear MIP model for designing a spatially coherent nature reserve system that provides protection to multiple cohabiting species. When selecting reserve sites, we consider a conservation resource limitation, interdependencies between the species' habitat needs, and spatial characteristics of the available habitat sites. We present an empirical application to the joint protection of two cohabiting species in a military installation in Georgia, USA. We test the computational efficiency of the model and investigate the trade-offs between spatial attributes and habitat quality.

2 - Modern Portfolio Theory to Formalize Diversification as an Explicit Strategy for Managing Risk in Climate-driven Reserve Design

Zulqarnain Haider, University of South Florida, Tampa, FL, 33613, United States, zulqarnain@mail.usf.edu, Mitchell J. Eaton, Simeon Yurek, Julien Martin, Fred Johnson, Bradley Udell, Hadi Charkhgard, Changhyun Kwon

Climate change and urban growth impact habitats, and species. Uncertainty regarding the scale of landscape change complicates reserve planning. We use principles of Modern Portfolio Theory, to formalize diversification as an explicit strategy for managing risk in climate-driven reserve design. Evaluating several climate risk profiles for a case study in South Carolina, our results suggest that budgets will likely be important determinants of conservation planning strategies, particularly when considering divestment. Optimal reserve design solutions are determined to improve expected losses while considering risk associated with sea level rise and urbanization.

3 - Optimizing Search and Control of EAB in Canadian Forests

Sabah Bushaj, New Jersey Institute of Technology, Newark, NJ, United States, sb2386@njit.edu, Esra Buyuktahtakin Toy, Denys Yemshanov, Robert Haight

Emerald ash borer (EAB) is one of the most damaging invasive species ever to reach the United States, killing millions of ash trees. In this study, we present a multi-stage stochastic mixed-integer programming (M-SMIP) formulation to minimize the damage caused by EAB in Canadian Forests. Our results provide insights into optimal timing and location of EAB surveillance and control strategies.

4 - A Network-based Approach to Assess the Trade-off Between Forest Management and Wildlife Protection Goals in Boreal Landscapes

Denys Yemshanov, Natural Resources Canada, Sault Ste. Marie, ON, P6A2E5, Canada, denys.yemshanov@canada.ca, Robert G. Haight, Mark-Andre Parisien, Ning Liu, Frank H. Koch, Quinn Barber, Cole Burton, Fabio Campioni, Salimur Choudhury

Wildlife protection is a critical priority in the areas of active forest management. We link a network-flow habitat connectivity model with a harvest scheduling model which finds optimal harvest regimes under the habitat connectivity objective. The model maximizes the amount of connected wildlife habitat while satisficing the forest harvest objective, subject to even harvest flow, harvested timber volume target and sustainability constraints. We apply the model to explore the trade-off between caribou protection measures and harvest in Canadian boreal forests - areas of prime caribou habitat.

■ WB45

CC- Room 614

Min-Max Optimization

Sponsored: Optimization/Nonlinear Programming

Sponsored Session

Chair: Aryan Mokhtari, Massachusetts Institute of Technology, Cambridge, MA, 02139, United States

Co-Chair: Asuman Ozdaglar, Massachusetts Institute of Technology, Cambridge, MA, 02139, United States

1 - A Doubly-randomized Block-coordinate Primal Dual Method for Large-scale Convex Concave Saddle Point Problems: Acceleration via Variance-reduction

Necdet Serhat Aybat, Penn State University, Penn State University, University Park, PA, 16802, United States, nsa10@psu.edu

We consider computing a saddle point (x*,y*) of convex-concave L(x,y)=\sum_{n=1}^N Phi_n (x,y). To contend with the challenges in computing full gradients, we employ a primal-dual scheme in which randomly selected primal and dual variable blocks, x_i and y_j, are updated at every iteration. When N is large, we can utilize an increasing batch-size of the gradients of Phi_n, to achieve the optimal rate of O(1/k) in terms of L(x^k,y*)-L(x*,y^k). This problem class includes convex optimization with a large number of constraints, and preliminary results on QCQPs with many constraints look promising.

2 - Learning via Non-convex Min-max Games

Meisam Razaviyayn, University of Southern California, Los Angeles, CA, 90089, United States, Maher Nouiehed, Maziar Sanjabi, Jason Lee

Recent applications that arise in machine learning have surged significant interest in solving min-max saddle point games. This problem has been extensively studied in the convex-concave regime for which a global equilibrium solution can be computed efficiently. In this talk, we study the problem in the non-convex regime and show that an ϵ—first order stationary point of the game can be computed when one of the player's objective can be optimized to global optimality efficiently. We discuss the application of the proposed algorithm in defense agains adversarial attacks to neural networks, generative adversarial networks, and generative adversarial imitation learning

3 - A Unified Analysis of Extra-gradient and Optimistic Gr adient Descent Ascent Methods for Saddle Point Problems: Proximal Point Approach

Sarath Pattathil, MIT, Cambridge, MA, United States, sarathp@mit.edu

In this work we study saddle point problems, and, in particular, we focus on two variants of Gradient Descent-Ascent algorithms, Extra-gradient (EG) and Optimistic Gradient Descent Ascent (OGDA) methods. We show that both of these algorithms admit a unified analysis as approximations of the classical proximal point method for solving saddle point problems. This viewpoint enables us to develop a new framework for analyzing EG and OGDA for bilinear and strongly convex-strongly concave settings. Moreover, we use the proximal point approximation interpretation to generalize the results for OGDA for a wide range of parameters.

4 - Negative Momentum for Improved Game Dynamics

Ioannis Mitliagkas, Université de Montréal, Montreal, QC, Canada

Games generalize the single-objective optimization paradigm by introducing different objective functions for different players. Differentiable games often proceed by simultaneous or alternating gradient updates. In machine learning, games are gaining new importance through formulations like generative adversarial networks (GANs) and actor-critic systems. However, compared to optimization, game dynamics are more complex and less understood. Our analysis shows that a negative momentum term can improve convergence. Our empirical results show that alternating gradient updates with a negative momentum term achieve convergence on the notoriously difficult to train saturating GANs.

■ WB46

CC- Room 615

Intersection Control and Optimization for Connected/Automated Vehicle Technologies

Sponsored: Transportation Science & Logistics/Intelligent Transportation Systems (ITS)

Sponsored Session

Chair: Michael Levin, Austin, TX, 78731, United States

1 - Lane-based Alternating Control Scheme: An Innovative Intersection Control Scheme Achieving Near-Optimal Throughput

Xi Lin, Tsinghua University, beijing, China, ghtttaifeng@126.com, Xiangdong Chen, Fang He, Yafeng Yin, Meng Li

This research proposed an intersection control scheme that achieves maximum throughput under mild assumption, called Lane-based Alternating Control Scheme (LACS). The control scheme assigns pre-set lane-based time windows to vehicles for entering an intersection, which allows the vehicle movements in all directions to work simultaneously without collisions. To further adapt the LACS to handle imbalanced demands, a hybrid scheme combining LACS with traffic signals (LA-TS) is proposed. Numerical experiments are implemented to compare the performances of LACS and LA-TS with some existing control schemes, and the results show that proposed schemes work well under various settings.

2 - Autonomous Intersection Management Applied to Realistic T raffic Scenarios

Aaron Parks-Young, Texas A&M, College Station, TX, United States, aaron.parks-young@tamu.edu, Guni Sharon

By relying on the fine and accurate control of connected and autonomous vehicles along with communication capabilities, intersection management protocols coordinate multiple vehicles simultaneously across an intersection. Previous publications have shown such protocols have potential to significantly reduce traffic delay for stylized traffic scenarios. In the proposed talk we will discuss adaptations to the known AIM simulator allowing it to simulate more real-to-life traffic scenarios as well as performance trends that arise from these scenarios.

3 - A Novel Trajectory Control Logic for Intersections with a Mix of Connected Human-driven and Automated Vehicles

Ramin Niroumand, Washington State University, Pullman, WA, United States, Mehrdad Tajalli, Leila Hajibabai, Ali Hajbabaie

This study proposes a new mathematical formulation to optimize the trajectory of connected human-driven and automated vehicles through traffic intersections. The underlying concept is to use traditional green and red signals under low connected and automated vehicle (CAV) market penetration rates. When the CAV market penetration rate is high enough, CAVs act as moving signals and control the movement of human-driven vehicles. Results indicate that the proposed method can work efficiently under various CAV market penetration rates.

4 - A Data-Driven Optimization Based Online Predictive Optimal Signal Control Model for Connected Signalized Intersections

Kuilin Zhang, Michigan Technological University, Civil and Environmental Engineering, 870 Dow Environmental Sciences, Houghton, MI, 49931, United States, klzhang@mtu.edu, Qinjie Lyu

We propose a data-driven optimization based online predictive traffic signal optimization model using real-time high-frequency connected vehicle data received at signalized intersections via vehicle-to-infrastructure communication technologies. An online learning algorithm is used to predict future traffic dynamics at signalized intersections using real-time mobile sensing data generated from connected and automated vehicles. The predicted traffic dynamics will be integrated into a data-driven optimization based control model for a robust optimal signal control under traffic uncertainty.

5 - A Lagrangian-based Signal Timing and Trajectory Optimization in a Mixed Connected and Automated Vehicle Environment

Mehrdad Tajalli, North Carolina State University, Raleigh, NC, 99163, United States, mtajall@ncsu.edu, Ali Hajbabaie

This study presents a mixed integer nonlinear program for integrated signal timing and trajectory optimization of connected and automated vehicles at signalized intersection to minimize total travel time and harmonize speeds. A lagrangian relaxation-based solution technique is developed that decomposes the problem into lane-group-level sub-problems. Numerical results show that the algorithm is capable of finding optimal solutions efficiently and improves traffic operations at signalized intersections.

■ WB47

CC- Room 616

Vehicle Routing IV

Contributed Session

Chair: Xingyin Wang, Singapore University of Technology and Design, Singapore, 487372, Singapore

1 - An Efficient Approximation Algorithm for Large-scaled Stochastic Combinatorial Optimization Problems

Yoko Ide, Mitsubishi Heavy Industry, Kanagawaken, Japan, yoko1_ide@mhi.co.jp, Kazuhisa Makino, Yo Morimoto

We propose an efficient approximation algorithm for large-scaled stochastic combinatorial optimization problems. Specifically, we focus on the vehicle allocation and production planning problems with uncertainty characterized by probability distributions for travel time and production lead time of the problems. Our algorithm makes use of a few scenarios to efficiently construct an approximate solution. We implement our algorithm by using Gurobi optimizer to demonstrate the effectiveness of the algorithm for large-scaled real-world problems.

2 - Impact of Drone Failures on the Drone Flight Schedule in a Delivery Application of Drones

Maryam Torabbeigi, University of Houston, Houston, TX, United States, maryam.torabbeigi@gmail.com, Gino J. Lim, Navid Ahmadian, Seon Jin Kim

One of the growing application of drones is in the parcel delivery. This study aims to provide flight paths for a group of drones such that the amount of demand that can be lost due to drones failures, will be minimized. Therefore the expected loss of demand (ELOD) is introduced here to obtain a more reliable flight schedule. A mixed integer programming (MIP) problem is provided that minimizes the ELOD and determines the assignment of customers to drones and the sequence of visiting them by drones. A SA heuristic algorithm is proposed to solve the large-size problems. The results show the impact of including drone failures in the scheduling.

3 - A Universal Routing Algorithm Including Parking Probabilities and Historic Travel Time Data

Mareike Hedderich, Bundeswehr University Munich, Munich, Germany

The daily challenges for an urban driver are finding a free on-street parking spot and meeting an arrival deadline at their destination. To overcome those problems, this paper presents an approach to combine two routing algorithms. The combination is called the universal routing algorithm and involves a park spot route using on-street parking information and a stochastic route using historic travel time data on street links. The result is a route that leads the driver through streets with high parking probabilities close to the destination and maximizes the probability of arriving on time. This paper presents a method on how to combine the two algorithms and shows some simulation results.

4 - Speed-up Heuristic for an On-demand Ride-pooling Algorithm

Roman Engelhardt, Bundeswehr University Munich, Neubiberg, Germany, roman.engelhardt@unibw.de, Florian Dandl, Klaus Bogenberger

Real-time assignments for large scale on-demand ride-pooling fleets is a challenging problem until today. In this study we compare a insertion heuristic algorithm with a state-of-the-art multi-step matching algorithm on trip data for Munich, Germany. Results indicate by using the multi-step algorithm up to 8% additional requests could be served while also 10% additional driven distance could be saved. To decrease computational time for the advanced algorithm, a vehicle selection heuristic is presented, which can speed up the most cost intensive algorithm step by a factor of 8, while keeping the number of served requests almost constant and maintaining 70% of the driven distance saved in the system.

5 - A Two-stage Solution Approach for the Directed Rural Postman Problem with Turn Penalties

Xingyin Wang, Singapore Univeristy of Technology and Design, Singapore, xingyin_wang@sutd.edu.sg, Carmine Cerrone, Benjamin Dussault, Bruce L. Golden, Edward Wasil

We consider the Directed Rural Postman Problem with Turn Penalties (DRPP-TP). A solution is a tour that traverses all required arcs of the graph. The cost of the tour is the sum of the lengths of the traversed arcs plus the penalties associated with the turns. An Eulerian tour-first turn-second approach has been proposed in the literature. In the first part of this paper, we identify several characteristics of an input instance that make the two-stage approach effective. In the second part of this paper, we describe an integer linear program that is combined with a local search algorithm. This combination produces high-quality solutions to the DRPP-TP in a reasonable amount of computing time.

■ WB48

CC- Room 617

Dispatching, Delivery, & Assignment

Sponsored: Transportation Science & Logistics/Freight Transportation & Logistics

Sponsored Session

Chair: Lei Zhao, Tsinghua University, Beijing, 100084, China

1 - Coordinated Delivery for Shopping Malls with Limited Docking Capacity

Ruidian Song, Tsinghua University, Tsinghua Student Building, No.15, Beijing, China, srd13@mails.tsinghua.edu.cn, Hoong Chuin Lau, Lei Zhao

Shopping malls can be densely located in major cities such as Singapore and Hong Kong. Due to limited docking capacity, uncoordinated deliveries to the tenants tend to result in congestion. A delivery coordination platform centrally schedules vehicle routes for multiple logistics providers, and simultaneously reserves dock timeslots for the deliveries. These decisions need to be made jointly against the backdrop of travel and service time uncertainty. We model this problem as a two-stage stochastic mixed integer program, and develop an adaptive large neighborhood search (ALNS) algorithm. Extensive numerical experiments demonstrate the effectiveness and efficiency of our approach.

2 - Dispatching in Liquefied Natural Gas Road Transportation

Yilei Wan, Tsinghua University, Beijing, China, wan-yl17@mails.tsinghua.edu.cn, Xue Luo, Lei Zhao

A liquefied natural gas (LNG) road transportation platform purchases LNG and dispatches a fleet of vehicles to load LNG at suppliers (e.g., liquefaction plants, storage terminals) and to deliver to customer sites (e.g., fuel stations). On each day, the platform dispatches and registers available vehicles to suppliers by a specified deadline. On the next day, the customer demands reveal and the platform dispatches loaded vehicles to satisfy these demands to maximize the overall profit. We model this problem as a two-stage stochastic mixed integer program, and develop an efficient algorithm based on adaptive large neighborhood search (ALNS).

3 - Heuristic Methods for the Locomotive Assignment Problem with DP

Camilo Ortiz-Astorquiza, Pontificia Universidad Javeriana, Bogota, Colombia, camiloortiz@javeriana.edu.co, Jean-Francois Cordeau, Emma Frejinger

In this talk, we present various algorithmic refinements on an IP formulation for a general variant of the Locomotive Assignment Problem at the tactical level in which the operating mode i.e. distributed power or conventional, is part of the decision-making problem. We also present two heuristic methods to obtain near optimal solutions. We discuss the potential benefits of the model and solution methods based on computational experiments from a case study for Canadian National Railways.

4 - Compact Routes in Vehicle Routing Problem with Time Windows in Postal Services

Alexis Bretin, Polytechnique Montreal & Gerad, Dept Math and Industrial Engineering, C. P. 6079 Succ Centre-Ville, Montreal, QC, H3C 3A7, Canada, alexis.bretin@polymtl.ca, Guy Desaulniers, Louis-Martin Rousseau

We will present a Branch-and-Price-Based Large Neighborhood Search algorithm to solve the Vehicle Routing Problem with Time Windows that arises in postal services (parcel deliveries). In this field, time window density happens to be sparse, as commercial customers have some, while personal customers may be visited without any time window restriction. Classic constraints and specific ones, such as minimum feeding curves of the sorting machines, have to be handled, as well as preferences for compact routes. Constraint Programming is used for pre-processing purpose.

5 - Same-Day Delivery using a Heterogeneous Fleet

Dirk C. Mattfeld, Technische Universität Braunschweig, Wirtschaftsinformatik, Braunschweig, 38106, Germany, d.mattfeld@tu-braunschweig.de, Jeannette Hermanns, Barrett Thomas, Marlin Wolf Ulmer

Due to cost pressure, environmental restrictions, and workforce shortages, service providers are testing a variety of different vehicle types to satisfy deliveries in urban areas. In this talk, we consider a fleet of different vehicle types to serve dynamically requesting customers for urban operational delivery. Each customer expects delivery from a depot before a deadline. Our objective is to minimize the expected third party delivery costs. We present a heuristic method that exploits the individual features of the vehicle types to determine good assignment strategies of customers to vehicles. Results indicate that the combination of vehicle and geography attributes drive assignments.

■ WB49

CC- Room 618

Inventory Management II

Contributed Session

Chair: Yan Liang, University of Toronto

1 - Dynamic Capacity Allocation under Lost Sales and Service Dependent Demand

Govind Lal Kumawat, Indian Institute of Management Ahmedabad, Ahmedabad, India, Debjit Roy, Felix Papier

We study the capacity allocation problem faced by a supplier under lost sales and service dependent demand. The supplier allocates a limited production capacity to heterogeneous customers. Any unmet customer demand is lost and impacts the future demand. Our research is motivated by a component supplier that supplies components to original equipment manufacturers in a heavy commercial vehicle market. We formulate the problem as a Markov decision process and derive optimal capacity allocation policies and structural results.

2 - On the Complexity of the Periodic Joint Replenishment Problem

Liron Yedidsion, Senior Research Scientist, Amazon, Seattle, WA, United States, yedidsion.liron@gmail.com, Alexander Tuisov

The Continuous Periodic Joint Replenishment Problem (CPJRP) has been one of the core and most studied problems in supply chain management for the last half a century. Nonetheless, despite the vast effort put into studying the problem, its complexity has eluded researchers for years. Although the CPJRP has one of the tighter constant approximation ratio of 1.02, a polynomial optimal solution to it was never found. Recently, the discrete version of this problem was finally proved to be NP-hard. In this research, we extend this result and prove that the CPJRP problem is also strongly NP-hard.

3 - Trade Credit Insurance: The Purchase Necessity and the Premium Cost-sharing Mechanism

Hongping Li, University of Science and Technology of China, Hefei, China, hpli@mail.ustc.edu.cn

We consider a supply chain consisting of an insurer, a manufacturer, and a capital-constrained retailer who get trade credit from the manufacturer. To avoid the default risk caused by demand uncertainty, the manufacturer and the retailer jointly consider the purchase of insurance. We explore decisions of each participant, the role of insurance and premium cost-sharing mechanism. Our results show that insurance is adopted by the manufacturer alone when she is highly sensitive to risk, which benefits all partners and partly coordinates the supply chain. Insurance impels more financing with lower wholesale price, and promotes higher order level. However, the retailer's default risk increases.

4 - On Average-cost Periodic-review Inventory Models with Lost Sales and Quasiconvex Costs

Yan Liang, University of Toronto, A-149, Math Tower, Toronto, ON, 11794, Canada, yan.liang@rotman.utoronto.ca, Eugene A. Feinberg

In this talk we discuss a stochastic periodic-review setup-cost inventory control model with lost sales and holding/shortage cost function satisfying quasiconvexity assumptions. We show that the family of discounted relative value functions is equicontinous and that this model satisfies sufficient conditions for the validity of the average cost optimality equations. This implies the average cost optimality of (s,S) policies and the pointwise convergence of the discounted cost value functions to the average cost value function as the discount factor increases to 1.

■ WB50

CC- Room 619

Transportation

Contributed Session

Chair: Shiqi(Shawn) Ou, Research Staff, Oak Ridge National Laboratory

1 - Nationwide Passenger Migration Forecasting: A Spatio-temporal Deep Learning Approach

Yuxin He, City University of Hong Kong, Hong Kong, Hong Kong, yuxinhe2-c@my.cityu.edu.hk, Yang Zhao, Kwok Leung Tsui

Forecasting passenger migration by exploring nationwide migration pattern is vital for migration management and effective allocation of national transportation resources. However, it is challenging as nationwide migration is affected by complex factors including spatial and temporal dependencies, and external factors. Using migration data from Tencent Location Big Data, this paper employs the deep spatiotemporal residual network (ST-ResNet) to simultaneously forecast inflow and outflow of migrants of cities in China. The experimental results show that ST-ResNet can well capture the spatiotemporal dependencies and outperforms state-of-art baselines in terms of forecasting accuracy.

2 - Co-evolution of Electric Vehicle Adoption and Charging Infrastructure Expansion Using Agent-based Modeling

Yan (Joann) Zhou, Group Leader, Mobility and Deployment, Argonne National Laboratory, Lemont, IL, United States, yzhou@anl.gov, Marianne Mintz, Charles M. Macal

We developed an agent-based model, Compass, to model short to long-term co-evolution of electric vehicles adoption and charging infrastructure expansion by quantifying the energy consumption, spatiotemporal charging demand and unmet demand/trips in Chicagoland. Compass models decisions of three agents, driver, household and investors through daily and annual simulation modules. Compass uses both bottom-up and top-down approach by 1) capturing the charging demand at given location/time based on travel pattern and number of vehicles, and 2) identifying the relationship between the density of charging stations and vehicle stocks using empirical data. Case studies will be presented.

3 - Collaboration in the Urban Solid Waste Collection Design

Alejandro Lamas, NEOMA Business School, Rouen, France, alejandro.lamas@neoma-bs.fr, Carola A. Blazquez

Collaboration between supply chains aims to gain from the synergies arising from collaborators. An extension of such initiative for the public sector is the design of the collection of the urban solid waste. District authorities design this collection independently between each other so a joint planning that enables sharing resources (e.g. vehicles, workers, etc.) may lead to more efficient collection. We propose a framework for jointly design the collection in such a way we minimize the global cost while meeting the individual goals of the participants. Due to the combinatorial nature of the problem, we propose a Benders decomposition approach for addressin real-life size instances.

4 - A Cost Reduction Model for the Management of Pipe Cars in the Brazilian Northeast.

Reinaldo Crispiniano Garcia, Operations Research Laboratory (www.orlab.com.br), Brasilia, Brazil, rcgar@yahoo.com, Magno Gonçalves da Costa, Diogo Samy, Ana Luisa Oliveira, Clovis Neumann, Rodrigo de Morais Balduíno Oliveira, Álvaro Café

The problem of delivering water in the Brazilian Northeast is a challenging one, with 30,000 communities and 4,000 reservoirs to deliver it. Some of the reservoirs have a limited capacity, mainly the water treatment plants (WTP), even though they have priority due to their water quality. The no. of reservoirs and communities change every month, since depending on the rainfall, either a reservoir can become dry or a community will not request water by the pipe cars in the next month. This work implements a model of the VRP, taking into account the communities demands, the reservoirs capacities and their water quality. The developed model shows an annual savings of US$ 100 million, about 25% of the total cost.

5 - A Method to Quantify the Impacts of Charging Infrastructure on Passenger Vehicle Market in China

Shiqi(Shawn) Ou, Research Staff, Oak Ridge National Laboratory, Knoxville, TN, United States, ous1@ornl.gov, Zhenhong Lin, Xin He, Steven Przesmitzki, Jessey Bouchard

This study integrates the charging infrastructure analysis into the market dynamics analysis tool - New Energy and Oil Consumption Credits model to assess the charging infrastructure (home parking ratio, public charging opportunity, and charging costs) impacts on PEV ownership costs and analyze how the PEV market shares may be affected by attributes of the current charging infrastructure in China. Parameter sensitivity analysis on industry profits is conducted. The simulation results support that the public charging infrastructure has more effectiveness on promoting the PEV sales in the PEV emerging market than it is in the PEV mature market.

■ WB51

CC- Room 620

Joint Session AAS/TSL Air: Dynamic decision-making Models in AAS Operations and Revenue Management

Sponsored: Aviation Applications

Sponsored Session

Chair: Marla Lavanya

1 - Managing Airline Delay Uncertainty by Adjusting Connection Slacks: A Stochastic Programming Approach

Sujeevraja Sanjeevi, Team Lead Operations Research, Sabre, Southlake, TX, United States, sujeev.sanjeevi@gmail.com

Adjusting flight connection time slacks is a popular strategy among airlines to hedge against uncertainty in flight delays. We propose a 2-stage stochastic programming model that makes controlled adjustments to flight departure times to minimize the expected value of excessive flight delays. We solve this model using an integrated framework that uses Benders decomposition and column generation. Our computational results show that such adjustments can help airlines make significant improvements in reducing propagated delays and improving on-time performance. Our talk includes implementation techniques for drastic reductions in run times of integrated frameworks like ours.

2 - Efficient Performance Bounds for Dynamic Airline Recovery Models

Lavanya Marla, University of Illinois at Urbana-Champaign, Urbana, IL, 61801, United States, lavanyam@illinois.edu, Jane Lee

We introduce an information-relaxation-based approach to bounding the performance of airline recovery models. In a multi-stage dynamic programming, we construct an omniscient ops controller with full information, and penalize this controller based on the additional information that is not available to a real-world controller who cannot know future disruptions. Our approach reveals practical bounds on recovery approaches that are tighter than full-information-based regret bounds.

3 - A Model to Incorporate Dynamic Offer Generation Into Airline Revenue Management Systems

Kevin Wang, Graduate Research Assistant, MIT, Cambridge, MA, United States, kevini@mit.edu

Dynamic offer generation tailors offers to different demand segments by bundling ancillary services with flight purchases. We formulate a revenue-maximizing algorithm that dynamically prices flight and ancillary offers based on passenger willingness-to-pay, combining dynamic pricing and ancillary-aware RM. We show how this algorithm integrates with traditional RM systems. The PODS simulator is used to illustrate the source and magnitude of potential revenue gains from dynamic offer generation. The results provide insights about the benefits, drawbacks and competitive effects of ancillary bundling.

4 - Dynamic Pricing Recommendations for Airline Ancillaries with Customer Context

naman shukla, University of illinois, Urbana, IL, United States, namans2@illinois.edu, Arinbjörn Kolbeinsson, Lavanya Marla, Kartik Yellepeddi

Ancillaries have become a major source of revenue and profitability in the travel industry. Yet, conventional pricing strategies are based on business rules that are poorly optimized. We present a pricing model that provides dynamic pricing recommendations specific to each customer interaction and optimizes expected revenue per customer. We propose a meta-learning approach for synchronous deployment of multiple models. We describe the performance of these models based on both offline and online evaluations. We also measure the real-world business impact of these approaches by deploying them in an A/B test on an airline's internet booking website.

■ WB52

CC- Skagit 1

Financial Engineering II

Contributed Session

Chair: Heletje E van Staden, PhD Student, KU Leuven

1 - The Leland Toft Optimal Capital Structure Model under Poisson Observations

Kazutoshi Yamazaki, Kansai University, Suita, Japan, kyamazak@kansai-u.ac.jp, Zbigniew Palmowski, Jose Luis Perez, Budhi Surya

We revisit the optimal capital structure model with endogenous bankruptcy first studied by Leland (1994) and Leland and Toft (1996). Differently from the standard case, where shareholders observe continuously the asset value and bankruptcy is executed instantaneously without delay, we assume that the information of the asset value is updated only at intervals, modeled by the jump times of an independent Poisson process. Under the spectrally negative Lévy model, we obtain the optimal bankruptcy strategy and the corresponding capital structure. A series of numerical studies are given.

2 - Dynamic Optimal Placement in a Limit Order Book under Variance Constraint

Hyoeun Lee, University of Illinois at Urbana-Champaign, Champaign, IL, United States, Jose E. Figueroa-Lopez, Raghu Pasupathy

We study the optimal placement problem of a stock trader who wishes to clear her inventory by a predetermined time horizon by using a limit order or a market order while controlling the variance. For a diffusive market, we characterize the optimal limit order placement policy under a variance constraint using two strategies: static and dynamic order placement strategy. We show that in the presence of a negative drift, there exist optimal placements for both cases. We also propose a simple method to approximate the optimal order placement with regard to the given variance constraint.

3 - Measuring the Endogeneity of the Cryptocurrency Market

Michael Mark, EPFL, Cugy(VD), Switzerland, Thomas A. Weber

To measure the self- and cross-dependence of the limit-order books for major cryptocurrencies, we estimate a nonparametric, mutually exciting Hawkes process. As the corresponding price processes are highly volatile and sensitive to news releases, we extend the standard law of motion for the arrival intensities by a kernel matrix representing the news impact. Using a hitherto untapped source of high-frequency cryptocurrency data, we construct a dynamic measure of the endogeneity of cryptomarket transactions.

4 - Uncertainty in Operating Leverage – A Foster Hart Risk Perspective

Ravi Prakash Ranjan, Eindhoven University of Technology, Eindhoven, Netherlands, miracle.ranjan@gmail.com, Shaunak Dabadghao, Arun Chockalingam

In this paper, we study the uncertainty in operating leverage and relate it to stability of heterogeneous set of firms. We define a coefficient of contribution margin (G) for a firm and understand its variation with degree of operating leverage. We quantify uncertainty in operating leverage using Foster-Hart (FH) risk where the fixed costs denote the threshold wealth in FH framework. We use the FH risk to assess whether the firm is in i) Safe Zone ii) Profit Making Zone with Risk, iii) Threat Zone and iv) Hazard Zone. Our subsequent analysis involves understanding how FH risk in operating leverage gets affected by firm's Cash Conversion Cycles and presenting empirical evidence for the proposed framework.

5 - Integrated Optimization of Maintenance Interventions and Spare Part Selections for a Partially Observable Multi-component System

Oktay Karabag, Postdoctoral Researcher, Eindhoven University of Technology, Eindhoven, Netherlands, o.karabag@tue.nl, Ayse Eruguz, Rob Basten

We consider a multi-component system in which a single condition parameter (e.g., vibration or temperature) is monitored. The outcome of monitoring indicates whether the system is functioning properly, is defective, or has failed. However, the condition signal does not reveal which component in the system is defective or has failed. The decision maker infers the exact state of the system from the current condition signal and the past data, in order to decide when to intervene for maintenance and which spare parts to take along. We model this system as a POMDP and examine the value of having better sensors in the system and the value of the optimal policy compared to more naive policies, numerically.

6 - Optimal Maintenance Policies of Partially Observable Systems with Costly Multi-sensor Observations

Heletje E. van Staden, PhD student, KU Leuven, Leuven, Belgium

Industry 4.0 technologies, including the Internet of Things, allows for increased access to the real-time monitoring of complex systems. In particular, it allows, by means of sensors, for the monitoring and fusion of data from multiple variables of complex systems, enhancing deterioration modeling. The different sensors may be deployed by different firms, such that the data may only be accessed at a fee. We investigate the effect of such costly multi-sensor data with uncertainty on the maintenance optimization problem. Using partially observable Markov decision processes, we derive insights into when costly sensor data should be acquired by developing optimal maintenance policies.

■ WB53

CC- Skagit 2

Joint Session RMP/Practice Curated: Market Design and Pricing for Ride-sharing

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Hamid Nazerzadeh, USC Marshall School of Business, Los Angeles, CA, 90089, United States

1 - Competition in Ride-hailing Markets

Amin Saberi, Stanford University, San Francisco, CA, 94105, United States, saberi@stanford.edu, Amir Ahmadinejad, Hamid Nazerzadeh, Nolan Skochdopole, Kane Sweeney

We present a model with two competing ride-hailing platforms. Riders choose the platform that maximizes their utility which is decreasing in price and waiting time. The drivers can accept trips from both platforms. We investigate whether competition can lead to a ``tragedy of the commons" and market failure as the platforms compete over the shared resource of open cars. We present a combination of theoretical results and numerical case studies, using parameters estimated from Uber data.

2 - Designing the Multi-modal Transit Marketplace

Chamsi Hssaine, Cornell University, Ithaca, NY, 90025, United States, ch822@cornell.edu, Siddhartha Banerjee, Samitha Samaranayake, Ragavendran Gopalakrishnan

We study the of design of a mobility marketplace: a centralized platform offering multi-modal trips that combie private firms like Lyft and Uber with public transit. We develop a framework for pricing multi-modal trips, with the objective of maximizing social welfare conditioned on ensuring that all commuters and transportation firms enjoy a weakly Pareto-improving outcomes. Our framework exposes tradeoffs between efficiency and fairness. Our results extend to incorporate common choice-models like the Multinomial Logit, marketplace subsidization, multiple mobility providers, and constraints on travel times and transit capacity.

3 - Incentivizing Optimal Locations in a Model of Spatial Competition with Stochastic Demand

J Massey Cashore, Cornell University, Ithaca, NY, United States

We study Nash equilibria in a stochastic strategic version of the facility location problem, modeling ridesharing and other two-sided marketplaces over networks. Specifically, given an assignment of agents to nodes, we study whether a payment mechanism exists under which the assignment is an equilibrium. Using a simple LP-based approach, we show that the welfare-optimal locations are incentivizable when the LP relaxation of the welfare optimization problem is integral. Finally, we study the efficacy of these payments using simulations based on the NYC taxi dataset.

4 - Dynamic Pricing for Ride Hailing Marketplaces

Hamid Nazerzadeh, USC Marshall / Uber Technologies, Los Angeles, CA, 90089, United States

Uber is running one of the largest marketplaces in the world that matches millions of riders and drivers together. One of the key features of Uber's marketplace is dynamic pricing, so called surge, that balances the demand for trips and the supply of available cars. The surge pricing also motivates drivers to relocate to parts of the city with higher demand. In this talk, I'll discuss the design and implementation of Uber's new driver surge mechanism.

■ WB54

CC- Skagit 3

Personalized Pricing and Revenue Management

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Sumit Kunnumkal, Indian School of Business, Hyderabad, 500032, India

1 - Dynamic Pricing with Demand Learning and Reference Effects

N. Bora Keskin, Duke University, Fuqua School of Business, Durham, NC, 27708-0120, United States, bora.keskin@duke.edu, Arnoud Victor den Boer

We consider a dynamic pricing problem with demand learning and reference effects. Customers are loss averse: they have a reference price that can vary over time, and the demand reduction when the selling price exceeds the reference price dominates the demand increase when the selling price falls behind the reference price by the same amount. Consequently, the demand function has a time-varying "kink" and is not differentiable everywhere. The seller neither knows the underlying demand function nor observes the reference prices. We consider several variants of this problem and design asymptotically optimal pricing policies.

2 - Pricing and Waiting Behavior of Individual Sellers in Electronic Marketplaces

Shweta Singh, University of Minnesota-Twin Cities, Minneapolis, MN, 55455, United States, shwetawipro@gmail.com, Guyves Achtari, Guang Li, Mikhail Nediak

We present an empirical study of the pricing and waiting behavior of individual sellers in an electronic marketplace and discuss its implications for design of price recommendation systems that target seller trade-off between revenue and time to sell.

3 - Prophet Inequalities on the Intersection of a Matroid and a Graph with Application to Network Revenue Management

Will Ma, Columbia University, 71 School Street, New York, NY, 02139, United States, Jackie W. Baek

We consider prophet inequalities on the intersection of a matroid and a graph, which improves approximation ratios in network revenue management. Our results generalize to the setting where personalized assortments are offered to each customer.

4 - Assortment Planning and Revenue Management with Customer "Inertia"

Sumit Kunnumkal, Indian School of Business, Ac 4 Level 1 4116, Hyderabad, 500032, India, sumit_kunnumkal@isb.edu, Sridhar Seshadri

We consider a situation where customers have a tendency towards sticking to their previously purchased item. We analyze the assortment decisions for a firm that has access to its customers' purchase history.

■ WB55

CC- Skagit 4

New Methods in Revenue Management and Pricing

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: N. Bora Keskin, Duke University, Durham, NC, 27708-0120, United States

Co-Chair: Nur Sunar, UNC, Chapel Hill, NC, 27517, United States

1 - Pricing Itineraries and Laminar Bayesian Selection

Rad Niazadeh, Stanford University, Stanford, CA, 94305, United States, rad@cs.stanford.edu, Nima Anari, Amin Saberi, Ali Shameli

In this talk, I consider matroid Bayesian online selection, with applications to selling flight itineraries. The goal is to find a pricing algorithm for serving a sequence of arriving buyers that maximizes the expected welfare (or revenue), where the allowable subsets of served buyers are characterized by a laminar matroid with constant depth. We give the first Polynomial-Time Approximation Scheme (PTAS) for the above problem. Our approach is based on rounding the solution of a hierarchy of LP relaxations that can approximate the optimum online solution with any degree of accuracy as well as a concentration argument that shows our rounding does not have a considerable loss in the expected welfare.

2 - Pricing and Assortment Optimization of Horizontally Differentiated Products with Incomplete Information

Boxiao (Beryl) Chen, University of Illinois-Chicago, Chicago, IL, 60607, United States, bbchen@uic.edu, Arnoud Victor den Boer

We consider a decision maker selling multiple horizontally differentiated products. Customers are heterogeneous in their preferred location, of which the distribution is unknown. We develop a nonparametric data-driven algorithm that learns the unknown customer information only from historical sales data.

3 - Optimal Bayesian Price Fine-tuning

Jue Wang, Smith School of Business, Queen's University, ON, K7L 3N6, Canada, jw171@queensu.ca

We consider the problem of optimally fine-tuning the price near a historically fixed price (incumbent price) to maximize the expected revenue over a finite horizon. We formulate the problem as a discrete-time Bayesian dynamic program and connect it to the Gauss-Weierstrass Transform through a reformulation. We prove that the optimal pricing policy has a simple and intuitively appealing structure. Incomplete learning is absent from the optimal policy if the belief precision stays under a switching curve, but may emerge when the belief precision jumps above that curve, especially near the end of the horizon. We also develop an efficient algorithm using the fast Gauss transform.

4 - The Effects of Dynamic Pricing on Upstream Decisions

Clark C. Pixton, Brigham Young University, Provo, UT, 84601, United States, cpixton@byu.edu

We consider dynamic pricing in a setting where price adjustments are made in response to a dynamic, feature-based demand forecast. We show that while the implementation of dynamic pricing increases the long-run average profit from the pricing decision, it has mixed effects on the firm's other related decisions (such as inventory policy) and the customers' welfare and operational decisions.

■ WB56

CC- Skagit 5

Marketing IV

Contributed Session

Chair: Bhavani Shankar Saripalli, Indian Institute of Management Indore

1 - Agency Selling or Reselling? The Impacts of Data-driven Marketing in a B2C Platform

Yan Xiaoyu, Tianjin University, Tianjin, China, tjuyanxiaoyu@163.com, Liu weihua

This paper studies a B2C platform's preferences between agency selling and reselling considering the option of DDM. Conclusions are as follows. First, the platform prefers agency selling only when the market size is moderate.This contrasts with the traditional view that agency selling will make the platform more profitable by mitigating the double marginal effect. Second, the sales mode with higher sales volume may not be more profitable within a certain market size. This also explains the phenomenon in practice that the platform with high sales volume generates low profit. Finally, in more cases, the platform adopting a reselling mode has a higher profit growth rate.

2 - Market Foresight of the Platform Economy - Incorporating Stakeholders Into Scenarios

Jiawei Gao, Hitotsubashi University, Kunitachi, Tokyo, Japan, gaojiaweijp@hotmail.com

The platform economy is facing opportunities and challenges in the future market. Moreover, multiple stakeholders are involved in the market foresight for the platform economy: company, service/product provider, customer, government, community, etc. A stakeholder analysis embedded scenario planning is proposed to addressing the following questions: what will platform economy market looks like in the next 5 years from the perspective of stakeholders. The key focal issue of concern for the stakeholders are going to be interrogated and the role-play is going to be performed in the experimental design.

3 - Informing Marketing Decision by the Use of FMRI

Josephine S. Akosa, Visiting Assistant Professor, University of Notre Dame, Notre Dame, IN, United States, jakosa@nd.edu, Melinda McCann

A reliable and valid application of functional brain imaging techniques to understand consumer behavior can help inform marketing decisions. In this study, we discuss a bootstrap-based false discovery rate (FDR) controlling procedure suitable for functional magnetic resonance imaging (fMRI) data analysis by incorporating a generally valid null distribution and shrinkage estimation into the original procedures of Benjamini and Hochberg (1995) and Benjamini et al. (2006). Our goal is to provide the consumer researcher novel ways of using fMRI data analysis to inform marketing strategies and maximize profits.

4 - Finding Best Alternative Brand Based on Perceived Quality and Perceived Value Before Purchasing

Satanik Mitra, IIT Kharagpur, Kharagpur, India, satanikmitra@iitkgp.ac.in

Perceived quality and Perceived value of a brand traditionally measured using primary surveys. In this work, we propose a methodology to estimate these values from online consumer reviews using aspect-based sentiment analysis techniques. We first clean the crawled data; extract the aspects using a semi automatic approach using dependency parser and analyze sentiment scores. The aspects are categorized into five clusters. TOPSIS, a multi criterion decision making algorithm, is used to rank the brands based on perceived quality scores.

5 - Prataap Snacks: Journey from Back Alleys to National Markets

Bhavani Shankar Saripalli, Assistant Professor, Indian Institute of Management Indore, Indore, India, bhavanishankar@iimidr.ac.in

Emerging markets present peculiar situations to marketers. Those who can identify right opportunities and introduce products gain success. Prataap Snacks (PS) is one such market player from India. PS succeeded in subsistence markets by introducing snacks in tea stalls located in back alleys of small towns of Madhya Pradesh state in India. Most subsistence customers who aggregate for daily wage work require a snack at lower cost. PS expanded its network to cater to children's market with variety of confectionery. TV advertising helped improve market share, but PS has to focus on innovation to attract more customers. This paper is a case study analysis.

■ WB57

CC- Yakima 1

Topics in Humanitarian Operations

Sponsored: Public Sector OR

Sponsored Session

Chair: Seyma Guvan Kocack

1 - Interdicting Reconfiguring Networks with Applications in Human Trafficking

Daniel Kosmas, RPI, Troy, NY, United States, kosmad@rpi.edu, Thomas Sharkey, John E. Mitchell, Kayse Lee Maass

We consider the problem of disrupting networks that will reconfigure themselves based on our selected interdiction problem. The objective of the interdictor is to minimize the maximum flow in the reconfigured networks. The motivating application is in disrupting human trafficking networks where the reconfigurations helps to model the consequences, included unintended ones, of selected interdiction decisions. We discuss structural properties of the network that result in not choosing any interdictions is optimal and what this means in the context of human trafficking.

2 - Analysis of Food Security and Market Participation for Farmer Households in Uganda

Jarrod D. Goentzel, Massachusetts Institute of Technology, 7Cambridge, MA, 02139, United States, Micaela Wiseman, Courtney Blair, Tim Russell

We randomly surveyed 498 smallholder farmers in regions across Uganda to inform market facilitation efforts supported by development organizations. Results indicate that food security is not a prerequisite for market participation, indicating that market development activities will reach this vulnerable population. We also find that distance to roads and markets does not affect market participation but does affect the intensity of farmer engagement.

3 - Prescriptive Analytics for Post-disaster Inspection Operations

Mathieu Dahan, Georgia Institute of Technology, Atlanta, GA, United States, mdahan@mit.edu, Andrew Lee, Saurabh Amin, Georgia Perakis

We present a prescriptive analytics approach for localizing failures in the aftermath of a natural disaster. We utilize the information provided by failure prediction models to calibrate the generic formulation of a stochastic team orienteering problem. We derive a compact mixed-integer programming formulation of the problem that computes an optimal a-priori routing of the inspection teams. We illustrate our approach using the data from (i) Houston's drainage network inspection after Hurricane Harvey, and (ii) SF Bay area's gas pipeline inspection after an earthquake.

4 - Gift-in-kind Acceptance Strategies Based on Institutional Mission

Michael H. Veatch, Gordon College, Department of Mathematics, Wenham, MA, 01984, United States, mike.veatch@gordon.edu

Corporate Gifts-in-Kind (GIK) to relief and development NGOs benefit the donor and the recipients; however, the transport/logistics cost falls on the NGO. We develop a strategy for accepting/declining GIK that captures its value to the NGO's mission based on current conditions of demand, inventory, and freight budget. A case study with World Vision's GIK program demonstrates how the strategy can in implemented in the donation process.

5 - Meeting Demand with Multiple Resources Geographically and Over Time

Arden Baxter, Georgia Institute of Technology, Atlanta, GA, United States, abaxter8@gatech.edu

Allocation of limited resources (e.g., in an emergency or during disaster response) is a complex task, especially when demand is spread geographically and over time, and may require the simultaneous presence of multiple resources. We model this coordinated resource allocation problem as an integer program, present complexity results, and share results from a computational study on various graph structures.

■ WB58

CC- Yakima 2

Resilient Infrastructure and Community Networks

Sponsored: Public Sector OR

Sponsored Session

Chair: Gabriela Gongora Svartzman, PhD Candidate, Stevens Institute of Technology, Hoboken, NJ, United States

1 - Trade-off Analysis Between the Vulnerability and Recoverability Investments for Interdependent Infrastructure Networks

Kash Barker, University of Oklahoma, Norman, OK, 73019, United States, Deniz Berfin Karakoc

Communities become more dependent on the critical infrastructure networks to exist and operate. However these networks become more interdependent on each other to function and more vulnerable against stressors. Thus studying their (i) preparedness and (ii) recovery become crucial especially due to the increasing frequency of natural disasters. We extend a resilience-driven multi-objective mixed-integer programming model for interdependent infrastructure network restoration scheduling such that it performs a trade-off analysis between the resource investment through recovery and preparedness planning. The approach is illustrated on the critical infrastructures in Shelby County, TN.

2 - A Simulation-based Approach to Modelling Disruptions and Quantifying Uncertainties in a Large-scale Urban Transit System

Steffen O.P. Blume, Doctoral Researcher, ETH Zürich, Zürich, Switzerland, steffen.blume@frs.ethz.ch, Michel-Alexandre Cardin, Giovanni Sansavini

Expanding complexity is taking its toll on the resilience of public transit systems. Despite many operational and technological improvements, disruptions are inevitable and growingly catastrophic to the ever-increasing urban population. In this work, we present a simulation testbed that captures the complexity and uncertainties associated with large-scale urban transport system disruptions. The testbed provides estimates of the expected variability of the system performance during the disruption and recovery cycle and enables flexible system designs that take into account the uncertainties associated with network operations and passenger demand.

3 - Machine Learning and Data Mining in Identification of Unhappy Communities

Alexander Gilgur, PhD Student, Stevens Institute of Technology, Hoboken, NJ, 07030, United States, agilgur@stevens.edu, Jose Emmanuel Ramirez-Marquez

Happiness is a complex phenomenon. However, it is important to identify unhappy communities that need improvement and contented communities to compare them with. Subjective well-being surveys have an intrinsic selection bias, excluding the depressed and suicidal population. Medical records too have a selection bias. Suicide attempt rate answers the question of general contentment, and we used it to separate counties into "unhappy" and "contented". We then analyzed metadata and sentiment of NYT readers' responses to articles mentioning such counties. This paper outlines our findings.

4 - Multifaceted Modeling for Smart Urban Systems

Renee Obringer, Purdue University, West Lafayette, IN, United States, robringe@purdue.edu, Roshanak Nateghi

Modeling urban resilience will become crucial as urban populations grow and the climate continues to change. The theorists among the urban resilience community have been aware of the multifaceted nature of urban systems for quite some time. However, the models currently put into practice often only include a single facet of the complex urban networks they seek to model. This may have led to some misrepresentations of the resilience of various urban systems, especially when those systems are highly interconnected. Here we present a novel framework to simultaneously model multiple performance metrics of urban systems and analyze their resilience to various shocks.

5 - Visual Resilience Evaluation in Multiple Public Transportation Systems

Gabriela N. Gongora Svartzman, Stevens Institute of Technology, Hoboken, NJ, 07030, United States, ggongora@stevens.edu, Jose Emmanuel Ramirez-Marquez

Public transportation systems are core infrastructures to cities and can be subject to unforeseen events. The novelty of this research resides in evaluating the resilience of public transportation (buses, subway, railroad) as a multi-layered and interdependent systems. Visual resilience of disruptions (different degrees) due to weather conditions, police events or even sports, are developed. Real and simulated behavior of multiple modes of transportation are compared, through their aggregated commuting times, the surrounding areas affected and the transportation alternatives they offer. Data visualization and urban computing are employed to analyze New York City as a case study.

■ WB58a

CC- Chelan 1

11:00-11:45 MemComputing, Inc. / 11:45-12:30 ProCogia

Vendor Tutorial

1 - MemComputing's MemCPU(tm) SaaS Application Tutorial

Fabio L. Traversa, MemComputing, Inc., La Jolla, CA, United States

MemComputing will provide a tutorial on the MemCPU™ SaaS application for solving Integer Linear Programming problems. The MemComputing technology represents a completely new computational paradigm that is fine tuned to solve exponential combinatorial optimization problems in polynomial time. The MemCPU SaaS is in beta test. Beta testers are given free access to the service for testing out their own problems. Come along to see if this has applicability in your environment.

2 - Accelerate your business insights with Azure and PowerBI

Daniella Mark, ProCogia, Bellevue, WA, United States

Organizations today are struggling with generating valuable insights as the data gathering and wrangling processes get more involved and complex. In order to make sense of ever-changing business requirements, analysts must source data from multiple end points and build a cohesive understanding. To tackle this problem, we have developed an automated Azure solution with a data pipeline capable of listening to multiple sources. The implementation then interacts with a PowerBI front end which presents the results in a multi-dimensional way. The solution is totally customizable to work with any API. This solution speeds up the delivery time of insights generation.

■ WB59

CC- Chelan 2

Advanced Maintenance Models

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Yisha Xiang, Texas Tech University, Lubbock, TX, 79409, United States

Chair: Zhicheng Zhu, Lubbock, TX, 79415, United States

1 - Opportunistic Condition-based Maintenance for a Degrading System with Individually Repairable Components

Nooshin Yousefi, Rutgers University, Piscataway, NJ, United States, no.yousefi@rutgers.edu, David Coit

An opportunistic condition-based maintenance is proposed for multi-component systems where each degrading component has competing failure modes of degradation and random shock. For systems functioning for a long time, components have been replaced several times and their initial degradation reaches a steady state behavior. For systems with high downtime costs, it is prudent to avoid system failure. When the maintenance team are sent to replace any component due to failure or on-condition replacement, there is an opportunity for other components to be preventively replaced. The optimal on-condition and opportunistic thresholds and inspection interval are found simultaneously.

2 - New Perspectives on Age Replacement under Non-stationary Replacement Costs

Shadi Sanoubar, University of Pittsburgh, Pittsburgh, PA, United States, SHS204@pitt.edu, Lisa M. Maillart, Oleg A. Prokopyev

In many equipment replacement settings, replacement costs increase in the age of the component, e.g., due to decreasing salvage value. We present analytical and numerical results that explore the effect of such age-dependency on the long-run cost rate and optimal replacement time under both cost rate-minimizing and availability-maximizing criteria. Additionally, for seasonal replacement costs, we compare a non-stationary myopic heuristic replacement policy to an optimal stationary replacement policy obtained via simulation.

3 - Selective Maintenance of Multicomponent Systems with Multiple Dependent Failure Modes

Cesar Ruiz, University of Arkansas, Fayetteville, AR, United States, caruizto@email.uark.edu, Haitao Liao, Edward A. Pohl

We propose a condition-based selective maintenance optimization framework for maximizing the reliability of a system with multiple components subject to multiple failure modes. In particular, we classify these failure modes into soft failures and hard failures. For the soft failures, we model the evolution of each performance measure as a stochastic degradation process. In addition, the hard failures depend on the degradation processes that change the parameters of failure-time distributions. We solve the optimization problem using a Differential Evolution (DE) heuristic.

4 - Condition-based Maintenance for Multi-component Systems: Modeling, Structural Properties, and Algorithms

Zhicheng Zhu, Texas Tech, Lubbock, TX, 79415, United States, Yisha Xiang

Condition-based maintenance (CBM) is recognized as a cost-effective maintenance strategy. However, most research on CBM focuses on single-component systems. Limited research has considered CBM for multi-component systems. In this paper, we study the CBM optimization problem for multi-component systems. We first develop a multi-stage stochastic integer model over a finite planning horizon. We then design two efficient algorithms to solve the two-stage model based on the structural properties. Our computational studies show that Algorithm 1 obtains optimal solutions to the majority of test cases in a reasonable amount of time and Algorithm 2 can find high-quality solutions quickly.

5 - Investigation of System Transient Behavior under Imperfect Maintenance

Suzan Alaswad, Zayed University, Khalifa City A, Abu Dhabi, United Arab Emirates, salaswa@gmail.com, Sinan Salman

This paper studies the impact of imperfect maintenance on the limiting availability of repairable systems. The imperfect repair is modeled using Kijima Type II virtual age model. The specific interest of this study is to investigate the transient behavior of the repairable system. While the results show that using preventive maintenance improves the steady-state availability of the system, it takes longer to achieve higher values of the limiting availability with more fluctuating transient behavior. This paper studies the tradeoff between higher steady state availability with longer fluctuated transient behavior, or a faster way to stabilize the system with lower steady-state availability.

■ WB59a

CC- Chelan 3

Data Mining VI

Contributed Session

Chair: Milad Afzalan, Virginia Institute of Technology, Blacksburg, VA, 24060, United States

1 - A Hybrid Approach of Machine Learning Methods with Genetic Algorithm Optimization for Improving Prediction Accuracy

Fatemeh Amini, Iowa State University, Ames, IA, United States, famini@iastate.edu

Compared with conventional datasets where the number of features are many fewer than the number of observations, today, data scientists often encounter ultra-high-dimensional datasets in which the number of features exceed number of observations. Genetic algorithms can be used as a feature selection method to select the best subset of features in order to predict the response variable as accurate as possible. In this paper, the focus is on regression datasets in which using genetic algorithms in conjunction with machine learning techniques, almost always provide us with higher prediction accuracy in comparison with just applying machine learning methods with regularization inside.

2 - A Data Analytic Framework for Breast Cancer Survivability

Zahra Sedighi Maman, Adelphi Univeristy, Garden City, NY, United States, zmaman@adelphi.edu, Alexa Mondello

Breast Cancer is the most common cancer diagnosed in women worldwide. With the advent of technology such as machine learning, and artificial intelligence, medical data can be further analyzed in addition to the manual analysis performed by medical professionals, which can lead to a more accurate prognosis. This paper lays out a framework to model breast cancer survival using Surveillance, Epidemiology, and End Results (SEER) data from 2004 to 2016 to predict survival in Females affected with breast cancer. Based on input data, the framework establishes criteria for unbalanced data, feature and machine learning algorithm selection for survival prediction.

3 - Opioid Related Adverse Drug Reactions Prediction Based on FDA Adverse Event Reporting Database

Dolzodmaa Davaasuren, The Pennsylvania State University, State College, PA, United States, Soundar Kumara

Opioid analgesics are widely used in the treatment of chronic, cancer and non-cancer related pain. In the recent years, the opioid epidemic has evolved rapidly, starting with an increase in opioid prescription. Based on the FDA Adverse Event Reporting Data, we performed extensive investigation on the opioid related adverse events in terms of patients' demographic, disease and other commonly prescribed drugs along with opioids. Also, we propose a machine learning algorithm for predicting adverse reaction and outcome resulting from the potential interaction among prescribed drugs for the disease and opioids.

4 - Community Structure and Sentiment Related to Brazilian Election Twitter Networks

Camila Pereira dos Tautenhain, Universidade Federal de São Paulo, São José dos Campos, Brazil, camila.p.san@gmail.com, Rodrigo Francisquini, Mariá Cristina Nascimento

Twitter is a platform widely used to express political opinions. In this study, we employed community detection methods to analyze networks constructed from tweets related to the Brazilian presidential elections. We verified that tweets that receive most of the retweets in these networks were viral and spread across several communities. The remaining tweets were trapped within the communities. Moreover, an analysis of the sentiments associated with the tweets revealed that words related to positive sentiments were more often in the communities. However, words associated with the highest negative sentiment scores were offensive.

5 - Smart and Context-aware Energy Demand Management: Data-driven Modeling for Automation in Buildings

Milad Afzalan, Virginia Tech, Blacksburg, VA, United States, afzalan@vt.edu

The adoption of data analytics and machine learning methods for management of infrastructures have received attention during recent years. Specifically, the technological advances in integration of distributed sensors and control systems are providing a large amount of data with opportunities for the formation of smart cities. In this work, through developing data mining and machine learning methodologies, I present my work on (1) autonomous systems for estimating energy information of buildings and (2) leveraging the impact of human-building interaction for improved distributed demand management. The findings shed light on adopting automation platforms for emerging smart buildings.

WB60

CC- Chelan 4

Quality Control With Spatially Dense Optical Metrology Data

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Anh Tuan Bui, Northwestern University, Evanston, IL, 60208, United States

1 - Structured Point Cloud Data Analysis via Regularized Tensor Regression for Process Modeling and Optimization

Kamran Paynabar, Georgia Tech, Atlanta, GA, United States, kamran.paynabar@isye.gatech.edu, Hao Yan, Massimo Pacella

Advanced 3D metrology technologies such as coordinate measuring machine and laser 3D scanners have facilitated the collection of massive point cloud data, beneficial for process monitoring, control and optimization. However, due to their high dimensionality and structure complexity, modeling and analysis of point clouds are still a challenge. In this article, we use multilinear algebra techniques and propose a set of tensor regression approaches to model the variational patterns of point clouds and to link them to process variables. The performance of the proposed methods is evaluated through simulations and a real case study of turning process optimization.

2 - Data-driven Sem Image Enhancement for Nanomaterial Analysis

Yanjun Qian, Assistant Professor, Virginia Commonwealth University, Richmond, VA, 23221, United States, Yu Ding

We propose a data-driven super-resolution (SR) algorithm to recover a high-resolution (HR) electron microscopic (EM) image from its low-resolution (LR) counterpart, saving time and efforts for high-quality imaging of nanomaterial. To recover the information loss between the resolution levels, a patch-based library is learned from a captured HR image of a partial area and its corresponding LR region. Our work is focusing on the properties of the EM image data and its differences from natural optical images. The proposed method improves the quality of input EM images, while other generic SR methods fail to do so. Our method also increases the accuracy of further analysis of the processed images.

3 - Defect Detection for Surfaces with Random Texture

Anh Tuan Bui, Virginia Commonwealth University, Technological Institute, Richmond, VA, 60208, United States, Daniel Apley

We develop an approach for detecting local defects in surfaces that have random texture (e.g., textiles or material microstructures). We first use generic supervised learning methods to characterize the stochastic behavior of "normal" in-control samples of the surfaces. Based on the residuals of the supervised learning model applied to new samples in a statistical process control context, we propose two spatial moving statistics for detecting local aberrations in the surfaces. We illustrate the approach using simulated and real examples.

4 - A Deconvolution Approach to Learn 3d Shape Distortion Mechanism

Mingdong Lyu, University of Southern California, Los Angeles, CA, United States, mingdonl@usc.edu, Qiang Huang

To achieve prediction and control of 3D printing accuracy, it is important to understand the mechanism of the layer-by-layer build-up effect and its impact on the 3D shape distortion. Given input layer geometries, a novel deconvolution learning framework is proposed to capture layer interactions and deviation accumulation. Experimentation in stereolithography (SLA) and Fused Deposition Modeling process are conducted to demonstrate the proposed approach.

WB61

CC- Chelan 5

Predictive Modeling and Optimization in Reliability Analysis and Complex System Control

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Dongping Du, Texas Tech University, Texas Tech University, Lubbock, TX, 79409, United States

Chair: Chen Kan, University of Texas-Arlington, Euless, TX, 76039-6215, United States

1 - A Condition-based Predictive Maintenance Optimization for Multi-component Systems Subject to a System Reliability Requirement

Yue Shi, Texas Tech University, Lubbock, TX, 79415, United States, Yisha Xiang, Weihang Zhu

In this paper, we develop a condition-based predictive maintenance decision-framework for a multi-component system. The proposed framework joins the long-term system inspection schedule based on historical data and the short-term dynamic grouping based on newly observed information. More accurate predictive reliabilities are obtained via Bayesian updating, and an efficient algorithm is developed to identify groups of components for preventive maintenance to meet the reliability requirement. Numerical results show that the proposed model can lead to significant cost savings and improved system reliability, and can incorporate dynamic information.

2 - Model Identification and Physical Exercise Control Using Nonlinear Heart Rate Model and Particle Filter

Zhiyong Hu, Texas Tech University, Lubbock, TX, 79415, United States, Dongping Du

This study presents a Heart Rate -based modeling and control framework to monitor physiological changes during exercise and optimize exercise intensity to capitalize exercise outcomes. Particle filter (PF) is used to identify HR model parameters and optimize the intensity of exercise, e.g., walking or running speed, based on the calibrated model. HR prediction is calculated from the calibrated model, and the treadmill speed is optimized by minimizing the difference between predictions and target HR. The modeling and control framework is validated with different case studies. The results demonstrate the advantageous of the proposed framework for personalized HR modeling and exercise control.

3 - Failure Event Prediction Based on Time-to-event Data with a Deep Learning Model

Congfang Huang, UW-Madison, Madison, WI, United States, chuang286@wisc.edu, Shiyu Zhou, Akash Deep

Although statistical models have been developed to predict system failures in the design of maintenance policies, they are not flexible with time-variant covariates. We propose a deep learning model which utilizes Recurrent Neural Network to deal with the time-to-event sequence data and relates the time information to event type by adding a time entry to the one-hot encoded event vector. Compared with conventional methods, our deep learning model performs better on both simulated data and real world log files data.

4 - Fault Detection Using Deep Semi-supervised Feature Extraction with Positive and Unlabeled Data

Xiaomeng Peng, Northeastern University, Boston, MA, 02148, United States, peng.x@husky.neu.edu, Xiaoning Jin

In this research, we propose a novel semi-supervised fault detection methodology for a vehicle suspension system with positive and unlabeled (PU) samples. Fault detection with PU data aims build a classifier to assign samples to two classes, i.e., healthy class and faulty class. A deep semi-supervised learning method integrated with physical-based domain knowledge is applied for feature extraction. The suspension system for a full car model is modeled using a simulation tool, SIMPACK to generate the synthetic multi-sensor data. Our results show the effectiveness of the proposed in fault detection with PU data.

WB62

CC- Tahoma 1

Data-Driven Decision Methods for Critical and Chronic Care Using Sensor Data

Sponsored: Health Applications

Sponsored Session

Chair: Chun-An Chou, Northeastern University, Boston, MA, 02115, United States

Co-Chair: Ying Lin, University of Houston, Houston, TX, 77204, United States

1 - A Machine Learning-enabled Partially Observable Markov Decision Process Model Prediction Framework

Zeyu Liu, University of Tennessee, Knoxville, TN, United States, zliu65@vols.utk.edu, Anahita Khojandi, Xueping Li, Rishikesan Kamaleswaran

Markov decision process models are commonly used in sequential decision making. In this work, we use this method to develop a novel predictive modeling framework. Specifically, we incorporate a machine learning method into an optimal stopping partially observable Markov decision process (POMDP) model to make predictions. We implement the framework for early predictions of sepsis, a life-threatening condition. The problem is solved using a modified Point-Based Value Iteration algorithm. Results show that the framework outperforms benchmark machine learning models.

2 - EEG/MEG Source Imaging with Probabilistic Hierarchical Graph Prior

Feng Liu, Massachusetts General Hospital, Harvard Medical School

Brain source imaging is an important method for noninvasively characterizing brain activity using Electroencephalogram (EEG) or Magnetoencephalography (MEG) recordings. Traditional EEG/MEG Source Imaging (ESI) methods usually assume that either source activity at different time points is unrelated, or that similar spatiotemporal patterns exist across an entire study period. The former assumption makes ESI analyses sensitive to noise, while the latter renders ESI analyses unable to account for time-varying patterns of activity. To effectively deal with noise while maintaining flexibility and continuity among brain activation patterns, we propose a novel probabilistic ESI model based on a hierarchical graph prior. Under our method, a spanning tree constraint ensures that activity patterns have spatiotemporal continuity. Comprehensive numerical studies using synthetic data on a real brain model are conducted under different levels of signal-to-noise ratio (SNR) from both sensor and source spaces. We also examine the EEG/MEG data under auditory and visual stimuli, in which our ESI reconstructions are neurologically plausible. Our method also shows accurate result for epilepsy patients. All the results demonstrate significant improvements of the proposed algorithm over the benchmark methods in terms of source localization performance, especially at high noise levels.

3 - Topological Pattern Recognition of Severe Alzheimer's Disease via Regularized Supervised Learning of EEG Complexity

Miaolin Fan, Northeastern University, Boston, MA, 02115, United States, fan.mi@husky.neu.edu

Alzheimer's disease is a progressive brain disorder with gradual memory loss that correlates to cognitive deficits in the elderly population. In this study, we aim to discover the altered spatio-temporal patterns of EEG complexity associated with AD pathology in different severity levels. Multiscale entropy is used as the complexity measure to characterize the nonlinear dynamics at multiple temporal scales. Further, we experimented on the EEG recordings collected from 123 participants and fed them to multivariate machine learning algorithms. The results showed that temporal and occipitoparietal brain regions were more discriminative for classifying severe AD cohort versus normal controls.

4 - Detecting Chronic Ankle Instability Using Koopman Operator-based Features of Gait Data

Chun-An Chou, Northeastern University, Boston, MA, 02115, United States

Up to 70% of individuals don't fully recover from single ankle sprains and eventually develop chronic ankle instability (CAI). Current diagnosis of CAI is manly based on self-report rather than objective biomechanical measures. The goal of this study is to analyze body movements as a dynamic system based on sensors on bilateral hip, knee, and ankle joints. By combining Koopman Operator and Dynamic Mode Decomposition, we can approximate the nonlinear dynamics of human movement for both CAI and healthy subjects through an infinite but linear space of observations and verify the information contained in Koopman Modes.

5 - Machine Learning Approach to Discover Circadian Rhythmicity Patterns from Telemetric Activity Data

Lin Ying, University of Houston, Houston, TX, United States, ylin58@uh.edu

Understanding the circadian rhythm regulations and their relevance to human health is critical for many chronic diseases prevention and treatment. Recent advances in sensing technology provides abundant of self-monitoring data that promotes the discovery of disease associated circadian rhythm patterns. However, characterizing the circadian patterns is challenged by the noisy monitoring data, individual-to-individual variations and patients' unknown health conditions. To mitigate these challenges, we developed a collaborative learning based hidden Markov model to discover the circadian patterns from patients' actigraphy data and validate their associations with disease.

6 - Detecting Chronic Ankle Instability Using Koopman Operator-based Features of Gait Data

Shaodi Qian

Up to 70% of individuals don't fully recover from single ankle sprains and eventually develop chronic ankle instability (CAI). Current diagnosis of CAI is manly based on self-report rather than objective biomechanical measures. The goal of this study is to analyze body movements as a dynamic system based on sensors on bilateral hip, knee, and ankle joints. By combining Koopman Operator and Dynamic Mode Decomposition, we can approximate the nonlinear dynamics of human movement for both CAI and healthy subjects through an infinite but linear space of observations and verify the information contained in Koopman Modes.

■ WB63

CC- Tahoma 2

Healthcare Operations and Analytics

Sponsored: Health Applications

Sponsored Session

Chair: Ujjal Kumar Mukherjee, University of Illinois, Urbana-Champaign, Champaign, IL, 61820, United States

1 - Precision Medicine in Oncology

Ujjal Kumar Mukherjee, University of Illinois, Urbana-Champaign, 306 Wohlers Hall, 1206 South Sixth Street, Champaign, IL, 61820, United States, ukm@illinois.edu

In this paper we present a data driven framework for implementation of of precision medicine related to proteasome inhibitor treatment of multiple myeloma. We use genetic data from real patients to test the decision framework.

2 - Drivers of Drug Quality Failure

In Joon Noh, Ohio State University, 2100 Neil Avenue, Columbus, OH, 43210, United States, noh.69@osu.edu, John Gray, Hyunwoo Park, George Ball

Using novel and comprehensive drug-level data obtained from the FDA and other publicly available sources, this study empirically examines the various factors that relate to quality failures of drugs in the pharmaceutical industry context. We investigate first-order drivers and moderators.

3 - Effect of Mass Gathering on Hospital Admission

Tiancheng Zhao, University of Illinois at Urbana-Champaign, Champaign, IL, 61820, United States, tz14@illinois.edu, Ujjal Kumar Mukherjee, Dilip Chhajed, Han Ye

Mass gathering refers to an event where a large number of people gather in one location for a short period. Due to increased population intensity, this may create critical health risks. In this paper, we use admission data from an Indian hospital during regular times and the Kumbh Mela, a massive religious gathering, to study the effect of mass gathering on hospital admissions. The result of our spatial-Poisson arrival model shows that the effect of mass gathering on hospital admissions is heterogeneous on different disease groups, and regions with different geographical and socioeconomic parameters. We use the results of our study to provide insights which can be useful for future events.

4 - An Economic Analysis of Patient Compliance Programs under a Risk-sharing Agreement for Chronic Disease

Hui Zhang, Lakehead University, 950 Oliver Rd., Faculty of Business Administration, Thunder Bay, ON, P7B 5E1, Canada, hzhang2@lakeheadu.ca

Risk-sharing agreements have been used by drug makers and payers to control uncertainties in drug usage. One innovative form aims to address the concerns of low adherence, in which the drug maker reduces the price for the payer if the adherence exceeds a prespecified threshold. I compare this form with a traditional one in which the drug maker reduces price if the health outcome is lower than a threshold. Patient compliance program is used to improve the adherence. I thus investigate who should run the program under both forms of risk-sharing agreements and how the program should be run.

5 - New Tools for Predicting a Hospital Readmission

Stacey Mumbower, University of South Carolina, 1014 Greene Street, Columbia, SC, 29208, United States, stacey.mumbower@moore.sc.edu, Ronda Hughes, John Brooks, Neset Hikmet, Benjamin Schooley

Utilizing a hospital's electronic health record platform, we added three risk assessment tools for nurses to use to standardize and improve the discharge planning process. Hospital readmissions were then predicted with the additional information, using both a standard approach and a machine learning approach to compare predictive ability.

■ WB64

CC- Tahoma 3

Modeling Uncertainty in Healthcare Systems

Sponsored: Health Applications

Sponsored Session

Chair: Michelle M. Alvarado, University of Florida, Gainesville, FL, 32611-6595, United States

Co-Chair: Behshad Lahijanian, University of Florida, Gainesville, FL, 32611, United States

1 - Consistent Nursing Home Staff Scheduling under Heterogeneous Service Demand

Lingling Zhang, Dalian University of Technology, Dalian, China, zhangll0519@mail.dlut.edu.cn, Nan Kong, Mingyang Li, Mingzheng Wang

The demand for nursing home care is growing rapidly. High staff turnover and assignment inconsistency have limited the delivery of quality care, partially due to lack of intelligent demand forecasting and adaptive staff scheduling. We formulate a two-stage mixed-binary stochastic problem with integer recourse for integrated optimization of nursing staff scheduling and assignment under demand uncertainty. We select promising scheduling patterns from a large set while adjusting the service duration to improve consistency staff assignment to residents. We apply progressive hedging to solve large-size instances and provide insights into the planning operations.

2 - Transient Modeling of Handoff Process in Hospital Emergency Department

Wenjun Zhu, University of Wisconsin-Madison, Madison, WI, United States, wzhu83@wisc.edu, Jingshan Li

The handoff process in hospital emergency department refers to the transitions of patient from ED to hospital floor. Due to congestion or coordination issues, delays in handoff processes are not uncommon, which may lead to adverse events. Thus, substantial attentions have been paid to improvement in these transitions. Most of them are either qualitative or case study based, or addressing the steady state performance only. However, the handoff process needs to be carried out in a fast and safe manner. Studying the transient behavior of the process is more important. In this talk, a Markov chain based transient analysis model of handoff process is presented to analyze the dynamic behavior of the process.

3 - Frequent Pattern Mining from Multivariate Time Series Data

Meserret Karaca, University of Florida, Gainesville, FL, 32607, United States, mkaraca@ufl.edu, Michelle M. Alvarado, Panayote (Panos) M. Pardalos

Frequent temporal pattern mining (FTPM) is the problem of detecting frequently appearing events from multivariate time series data. This is a recently emerging problem with applications in medical event detection, equipment malfunction detection, environmental monitoring, etc. This study proposes a hybrid pattern mining approach for the FTPM problem. The FTPM problem has two steps: (i) generating patterns known as candidates, (ii) identifying the frequently occurring patterns. The goal of the study is to create a faster FTPM algorithm by preventing the generation of redundant candidates.

4 - Chance-constrained Stochastic Programming Model for Reducing Hospital Readmissions

Behshad Lahijanian, University of Florida, Herbert Wertheim College of Engineering, Industrial and Systems Engineer, Gainesville, FL, 32611, United States, b.lahijanian@ufl.edu, Michelle M. Alvarado

In response to the Hospital Readmission Reduction Program (HRRP), hospitals are seeking care strategies to reduce their readmission rates. We develop a scenario-based stochastic model as a multi-condition care strategy with probabilistic constraints to help hospitals prioritize treatment plans. The hospital aims to identify care strategies that provide a confidence level that the target readmission probability will be achieved. We explored the trade-off between the cost of care, probability of readmission, and confidence levels.

5 - Sequential Clinic Scheduling with Reentrance for Mohs Micrographic Surgery

Michelle M. Alvarado, Assistant Professor, University of Florida, Gainesville, FL, 32611-6595, United States, alvarado.m@ufl.edu, Haolin Feng, Mark Alan Lawley

Mohs Micrographic Surgery (MMS) is a surgical method used for the excision of skin cancers in areas of cosmetic importance, but is burdened by long in-clinic wait times due to the stochastic nature of layer removal. We develop a sequential stochastic scheduling method that balances patient wait time, clinic overtime and revenue while considering stochastic complications such as no-shows, processing time variance and reentrance. On average, simulation results indicate an approximate 34.6% improvement in objective function value over current practice, and a 24.6% improvement over models that ignore re-entrance.

■ WB65

CC- Tahoma 4

Healthcare Operations

Sponsored: Health Applications

Sponsored Session

Chair: Guodong Pang, Penn State University, University Park, PA, 16802, United States

Chair: Silviya Valeva, Rice University, Houston, TX, 77098, United States

1 - Optimizing Patient Flows in the Intensive Care Units - Downstream Wards Network

Silviya D. Valeva, Rice University, Houston, TX, 77098, United States, silviya.valeva@rice.edu, Guodong Pang, Andrew J. Schaefer

Intensive care units (ICUs) are expensive and high-demand resources treating critically ill patients that often act as a bottleneck in the hospital system. Coordinating the transfer of patients from ICUs to downstream units is usually handled by a single person and can cause significant delays and consequently block ICU bed access for incoming patients. We propose decision models and efficient solution approaches for the transfer and allocation of patients that maximize total ICU utility. Our models further incorporate flexible capacity, staffing, and fairness allocation as measures to hedge against peak demand and stress on the ward. We offer managerial insights based on simulation studies.

2 - Data Driven Inpatient Bed Assignment: AP Model Approach to Boarding and Overowing

Shasha Han, National University of Singapore, NUS Business School, Biz 2 Building B1, 1 Business Link, Singapore, Singapore, shashahan@u.nus.edu, Shuangchi He, Hongchoon Oh

We study inpatient bed assignment to shorten boarding times without excessive patient overflowing. We provide a practicable approach to solving the bed assignment problem. This data-driven approach captures critical features of patient flow management, while the resulting optimization problem is practically solvable. The proposed approach is a useful tool for the control of queueing systems with time-sensitive service requirements.

3 - Inpatient Overflow: An Approximate Dynamic Programming Approach

Pengyi Shi, Purdue University, Krannert School of Management, Kran 472, West Lafayette, IN, 47907, United States, shi178@purdue.edu, Jim Dai

Due to the inherent variations in arrivals and discharges, hospital managers may assign a patient to a non-primary inpatient ward, especially when the patient has boarded in the Emergency Department (ED) for several hours. Such overflow practice helps alleviate ward congestion but may compromise the quality of care. We formulate this overflow decision problem as a Markov decision process (MDP) within a multi-class, multi-pool queueing network setting. To overcome the curse-of-dimensionality, we develop an approximate dynamic programming (ADP) algorithm, where we use a novel combination of a fluid control model and an integrated single-pool model to guide the choice of the basis functions.

4 - Joint Capacity and Pricing Design for a Telehealth Network Model

Lan Jin, Pennsylvania State University, University Park, PA, 16803, United States, lxj84@psu.edu, Guodong Pang, Hui Zhao

We develop an optimal joint capacity design and pricing scheme for the operations management of a tele-health network. This network comprises local hospitals and a center. Local hospitals consider joining the network according to their utility and the costs including membership fee and service payment. The center decides the sta ng and prices to charge simultaneously. Within this framework, we consider small and large demands, which are motivated by two applications: sexual assault tele-center and tele-imaging diagnosis center. We discuss two variations of the current model: one di erentiating internal and external hospitals and the other di erentiating large and small scale hospitals.

5 - Supply Disruptions in Competing Drug Supply Chain

Parshuram Hotkar, University of Texas-Austin, McCombs School of Business, Austin, TX, 78712-1277, United States, Diwakar Gupta

We study the impact of information sharing in a competing drug supply chain where the firms are susceptible to a supply disruption. We find that the firms benefit from the visibility of the supply disruption as the firms can utilize their capacities efficiently. However, in equilibrium, the firms will invest in lower capacities which will result in lower drug supply.

■ WB66

CC- Tahoma 5

Reliability I

Contributed Session

Chair: Huichao Liu, Beihang University

1 - Integrated Equipment and Storage Design and Maintenance Policy Design Optimization for Reliable Air Separation Units Based on Markov Decision Process

Yixin Ye, Carnegie Mellon University, Pittsburgh, PA, United States, Ignacio E. Grossmann, Jose M. Pinto, Sivaraman Ramaswamy

Gas supply interruptions to customers can cause economic losses in Air Separation Units. As opposed to commonly used discrete event simulations, we propose an MILP model to simultaneously select equipment redundancy, storage, and maintenance policy optimizing the economic performance, where the degradation and maintenance activities are modeled as Markov Decision Processes. The resulting optimization model is solved through decomposition by processing stages to form a team game, where the stages (players) contribute individually to the system economic objective under the impacts of other players.

2 - Multi-objective Optimisation for Fault Tolerant Railway Network Design

Claudia Fecarotti, Eindhoven University of Technology, Eindhoven, Netherlands, c.fecarotti@tue.nl

This talk focuses on developing design strategies to improve the fault tolerance of railway networks. Crossovers improve the flexibility of the network by enabling trains to switch track, but they also contribute to failures occurrence and related risks. The problem of determining the optimal number and location of crossovers to achieve the required level of network availability under budget and performance constraints is formulated as a bi-objective nonlinear mixed-integer model based on the Set Partitioning. Solutions are addressed for a worst case and an average case disruption scenarios, where the maximum and average flow loss due to sections unavailability is minimized respectively.

3 - Discretizing Continuous-time Continuous-state Deterioration Processes, with an Application to Condition-based Maintenance Optimization

Bram De Jonge, Assistant professor, University of Groningen, Groningen, Netherlands, b.de.jonge@rug.nl

We present an approach for discretizing stationary continuous-time continuous-state non-decreasing deterioration processes. This results in a discrete-time Markov chain that is represented by its transition probability matrix. We consider the gamma deterioration process as a special case and use the discretization approach combined with matrix algebra to optimize condition-based maintenance for a continuously monitored single-unit system.

4 - Joint Effects of Local and Global Load Redistribution Model on Mixed Cascading Failures in Network Systems

Jian Zhou, PhD Candidate, Rutgers University, Piscataway, NJ, United States, zhoujian977913@gmail.com, David W. Coit, Frank A. Felder

A new model has been developed to analyze the impacts of network load redistribution on cascading failures in network systems. It provides distinct advantages in investigating the effects of combined load redistribution through system overloaded failures. Network load can be redistributed in the neighborhood of failed system components and globally based on system dependency. The new model extends previous research by taking both local and global load redistribution into account. Simulation of cascading failures is conducted on western U.S. power transmission grid topology for validation. The proposed model provides insights on load dynamics on system robustness against cascading failures.

5 - Research on Technical Framework of Helicopter Transmission System Reliability

Huichao Liu, Beihang University, Beijing, China, Wei Wang

Based on the analysis of the functional structure of helicopter transmission system, this paper constructs a technical framework for reliability design analysis and verification, which can guide the development of helicopter transmission system reliability and improve its reliability level. The results have certain reference value and guiding significance for the development of helicopter transmission system reliability and the improvement of its level, and are conducive to the improvement of helicopter transmission system reliability.

■ WB67

S- Virginia

Optimization, Combinatorial I

Contributed Session

Chair: Amit Verma, Missouri Western State University

1 - Solving an Integrated Coverage Problem for Heterogeneous Sensor Networks

Mumtaz Karatas, Assoc. Prof., National Defense University, Naval Academy, Istanbul, Turkey, mumtazkaratas@hotmail.com, Ertan Yakici

Coverage is the most important performance metric for sensor networks. In this study, we consider an integrated area, point and barrier coverage problem in which a decision-maker seeks to locate a number of heterogeneous sensors along a two-dimensional belt-shaped region. We formulate the location problem as an integer non-linear program and an equivalent integer linear program. We, then, develop a heuristic approach to solve the problem and compare their performances in terms of solution quality and computation time.

2 - Optimizing the Ordered Recommendation List in E-commerce Sites via Quadratic Assignment Problem

Ayaka Shigematsu, Osaka University, Osaka, Japan, Naoki Nishimura, Shunji Umetani

Some of the recent recommender systems do not focus on increasing only the accuracy of listed items for matching the users' interests but their diversity. We consider specifying the ordered recommendation list to avoid the similar items placing in the neighborhood, and formulate this problem as the quadratic assignment problem. To improve computational efficiency, we develop a two-stage algorithm that selects top-N recommendation items and specifies their order to maximize its diversity. We have tested our algorithm for a real recommender system and obtained reasonable recommendation lists.

3 - A SHOT at Nonconvex MINLP

Andreas Lundell, Åbo Akademi University, Turku, Finland, andreas.lundell@abo.fi, Jan Kronqvist

The Supporting Hyperplane Optimization Toolkit (SHOT) is an open-source, polyhedral outer approximation-based, state-of-the-art software originally developed for solving convex mixed-integer nonlinear programming (MINLP) problems. Until recently, it had no specific support for solving also nonconvex problems. In this talk features such as convexity detection, automatic reformulations, infeasibility repair, and objective cuts, recently added to SHOT are described. These additional features make SHOT a heuristic solver for nonconvex problems. In addition, SHOT can also guarantee the globality of the obtained solution in some special cases.

4 - Minimal Quadratic Unconstrained Binary Optimization (QUBO) for Max 3-SAT

Amit Verma, Assistant Professor of Supply Chain Management, Missouri Western State University, Saint Joseph, MO, United States, averma@missouriwestern.edu, Mark Lewis, Gary Kochenberger

Max 3-SAT is a well-known and important problem with wide applicability. Quadratic Unconstrained Binary Optimization (QUBO) has received much attention recently as a unifying framework for modeling a wide range of problems that can be solved with a generic approach such as quantum annealing hardware. In this paper, we investigate the use of penalty functions to model Max 3-SAT as a QUBO. We employ a cubic-to-quadratic transformation that minimizes the number of additional variables required in the QUBO and then preprocess the QUBO using a set of logical inference rules for further reduction prior to solution. Empirical testing illustrates the efficacy of the approach.

■ WB68

S- University

Manufacturing II

Contributed Session

Chair: Hani Khalil, University of Wisconsin-Milwaukee (UWM), 4848 n Lydell ave apt 405, Milwaukee, WI, 53217, United States

1 - A Sequential Value Correction Heuristic for a Two Dimensional Cutting Process with Defective Plates

Andrea Pizzuti, Università Politecnica delle Marche, Ancona, Italy, a.pizzuti@pm.univpm.it, Fabrizio Marinelli

Industrial cutting problems are generally complicated by several details related to the type of material being cut and the characteristic of the cutting machines. In this work we deal with a three-stage two-dimensional cutting stock problem where parts must be obtained by plates with defects and according to a given

partial order. We proposed a sequential value correction heuristic that computes profitable cutting patterns by a dynamic beam search strategy. The performance of the proposed algorithm is evaluated on a set of real-world instances provided by a prominent glass manufacturer.

2 - A Robust Optimization Model for the Assortment and Cut of Defective Sheets in Glass Production

Fabrizio Marinelli, Associate Professor, Universita' Politecnica delle Marche, Ancona, Italy, fabrizio.marinelli@staff.univpm.it, Claudio Arbib, Mustafa C. Pinar

A cutting process in the production of automotive glass parts is organized in two phases: (1) an assortment of large rectangular sheets is obtained by cutting a ribbon of melted glass after cooling, (2) small rectangular items are cut from large ones, and then bent and refinished. We address the problem of fulfilling given requirements by choosing and cutting a limited assortment of large sheets with a minimum trim loss, under unpredictable defects (e.g., bubbles) occurring in the sheets. To this aim we use a robust optimization model based upon a suitable Bertsimas-Sim uncertainty set.

3 - An Optimization Model for Automated Guided Vehicle (AGV) Scheduling with Battery Charging Systems

Minsoo Kim, KAIST, Daejeon, Korea, Republic of, minsookim92@kaist.ac.kr, Young Jae Jang

Recently, the manufacturing systems often utilize Automated Guided Vehicles (AGVs) to return logistics. These systems include battery points in the AGVs path to supply the power of the vehicles. However, this is prone to congestion because AGVs interfere with each other at the battery points. We propose an optimization model for AGV scheduling with battery charging systems. We, then, compare the performance of the policy obtained by the model with that of different various policies using simulation. Finally, we analyze the effect of AGV battery charging policy on AGV operational efficiency.

4 - Distance and Matching-induced Search Algorithm for the Multi-level Lot-sizing Problem with Substitutable Bill of Materials

Mingyuan Wei, Tsinghua University, Beijing, China

This study examines the multi-level capacitated lot-sizing problems with a special focus on item replaceability. A matching-induced search algorithm to solve the problem is proposed, which leverages the matching between the rounded relaxation and the incumbent solution values. The algorithm is further enhanced by using both the matching information of historical feasible solution values and the distance between the relaxation and incumbent solution values. Extensive computational experiments are conducted to test the efficiency of algorithms. Experimental results show that the proposed enhanced algorithm can perform better than some other heuristics in the literature.

5 - A Study on the Cutting Force Prediction Model of Milling Process

Jeongin Koo, Korea Institute of Industrial Technology, Cheonan, Korea, Republic of, jikoo@kitech.re.kr, Dongil Kim

Predicting the cutting force of milling processes is important because it is connected with machining quality such as surface roughness. This study presents the cutting force prediction model based on machine learning approaches. To build models, we collect the data from cutting experiments by CNC machine and the pre-cutting simulation model. Using those data, we develop a cutting force prediction model and conduct experiments how the model predicts cutting forces. Experimental results show that the model can predict cutting forces depend on process conditions such as rpm, feedrate, and the depth of cut.

6 - Sequential Acceptance Sampling Using Reinforcement Learning as a Critical Success Factor for Lean Six Sigma

Hani Khalil, PhD Candidate, University of Wisconsin-Milwaukee (UWM), Milwaukee, WI, United States, Dr. Wilkistar A. Otieno, Mark Halstrom

The successful implementation of lean six sigma - LSS is highly dependent on the critical success factors-CSFs. The literature review on the CSFs of LSS have not shown any work that studied whether acceptance sampling plans can be considered as a CSF for LSS (particularly sequential sampling). Reinforcement learning-RL is different from the other types of machine learning, it is a method of self-learning and acting based on observed data. The aim of this work is to develop a model based on coupling RL and sequential sampling to improve LSS in process and product monitoring. The result will show the integration of sequential sampling and RL as a key CSF for LSS implementation in the manufacturing industry.

■ WB69

S- Seneca

Joint Session Telecom & Network Analysis/Practice Curated: Topics in Telecommunications and Network Analytics

Sponsored: Telecommunications and Network Analytics

Sponsored Session

Chair: Austin Buchanan, Oklahoma State University, Stillwater, OK, 74078, United States

1 - Smart Ports (in Maritime Shipping): Is It a Case for Telecommunications?

Stefan Voss, University of Hamburg, Hamburg, Germany, Leonard Heilig, Adriana Moros

Digital transformation in maritime shipping subsumes smart port initiatives, which are related to connected platforms, mobile devices and apps, cloud-based services, IoT technologies, augmented reality etc. Real-time monitoring of almost every part of todays supply chains is becoming reality and only very short time is needed to react to or anticipate any sort of changes, disturbances and alike. We survey the trend of smart port initiatives and show how telefommunications helps in an indispensable way.

2 - New Models and Preprocessing Techniques for Segment Routing Optimization

Bernard Fortz, Université libre de Bruxelles, CP 212 Bld Du Triomphe, Bruxelles, 1050, Belgium, bernard.fortz@ulb.ac.be

Segment routing is a modern variant of source routing in computer networks. In a segment routed network, an ingress node may prepend a header to packets that contains a list of segments, which are instructions that are executed on subsequent nodes in the network. Such an instruction may be an instruction to forward a packet to a specific destination.

We present models for traffic engineering in a network implementing segment routing on top of shortest paths routing protocols. We also present some preprocessing techniques that allow to decrease significantly the size of the resulting models, and present numerical experiments validating the approach on a large set of test instances.

3 - Optimal Fixed Location M/m/s Server Allocation Using Network Flows

Adam Quentin Colley, Southern Methodist University, 1814 Tune Ave, Florence, AL, 35630, United States, acolley@smu.edu, Eli Olinick

We consider a server allocation problem in which a fixed number of servers is to be allocated to a fixed number of locations such as distributing a given number PBX's across multiple corporate campuses. In this model, a fixed number of servers has been predetermined along with the fixed locations to which one or more servers must be allocated. Demand at each location is stochastic with a known mean and variance. Since the cost model is convex and nonlinear, we present a two-step approach to solving the problem that first determines costs based on the M/M/s model. The costs are then input to a min-cost network flow model to optimally allocate the servers across the locations.

■ WB70

S- Jefferson A

Queueing Models

Contributed Session

Chair: Fatemeh Aarabi, University at Buffalo, Amherst, NY, 14228, United States

1 - A New Approximation for G/G/c Queues

Abhijit Gosavi, Associate Professor, Missouri University of Science & Technology, Rolla, MO, United States, gosavia@mst.edu, Carlos Chaves

Existing closed-form models in the literature for multi-server queues with generally distributed inter-arrival and service times (G/G/c) are often not accurate. Further, one does not always have extensive data for the input random variables, and only the values of means and variances are available. A new approximation, based on means and variances of the inter-arrival and service times, for the medium traffic G/G/c queue is presented. The new approximation generates encouraging numerical evidence for gamma-distributed inter-arrival times, often found in many manufacturing and service settings, and double-tapering distributions, such as normal, triangular, and gamma, for the service time.

2 - Decomposition Based Approaches for Tandem Polling Queues

Ravi Suman, University of Wisconsin-Madison, Madison, WI, United States, rsuman@wisc.edu, Ananth Krishnamurthy

We develop a decomposition-based approach to analyze tandem polling queues under different strategies, namely the independent, synchronous polling, and out-of-sync strategies. Using a decomposition approach, we estimate queue lengths and waiting times, compare the performance under different settings, and provide managerial insights for applications in manufacturing and healthcare.

3 - Conditional Waiting Time Analysis in Tandem Polling Queues

Ananth Krishnamurthy, Professor, University of Wisconsin-Madison, Madison, WI, United States, ananth.krishnamurthy@wisc.edu, Ravi Suman

We analyze a tandem network of polling queues with two product types and two stations under Markovain settings. For this system, we determine the mean conditional waiting time for a customer using sample path analysis that classifies system state upon arrival into scenarios and exploits an inherent structure in the sequence of events that occur till the customer departs.

4 - A Parametric-decomposition Methodology for Solving Queueing Networks with Capacity Restrictions and Simultaneous Resource Possession

Ronny Pacheco, PhD Student, Oklahoma State University, Stillwater, OK, United States, ronnyp@okstate.edu, Manjunath Kamath

Motivated by applications in healthcare systems, we consider queueing network models with capacity restrictions in different sections and one or more instances of simultaneous resource possession. By analyzing a diverse set of scenarios, we develop a building-block approach to solve more general situations. Our approach builds on the parametric-decomposition method and two-moment approximations for fork-join queues. Numerical examples will be presented to illustrate the application of the proposed methodology.

5 - Exact and Approximate Methods for Comparing Resource Allocation Strategies for Biomanufacturing Projects

Yasemin Limon, University of Wisconsin-Madison, Madison, WI, United States, ylimon@wisc.edu, Ananth Krishnamurthy

We analyze resource allocation challenges in protein purification operations where differences in scientist capabilities can lead to significantly different outcomes. We use queuing models to capture the underlying dynamics and quantify the performance of different strategies based on solutions obtained using the Matrix-Geometric approach. We show that a simple server utilization metric can be very effective in rank ordering strategies.

■ WB71

S- Jefferson B

Emerging Research in Behavioral Operations

Sponsored: Behavioral Operations Management

Sponsored Session

Chair: Stephen Leider, University of Michigan, Ann Arbor, MI, 48109, United States

1 - Using Wait Time Information to Nudge Patients' Waiting Experience in the Emergency Department

Danqi Luo, Stanford University, Stanford, CA, 94305, United States, dluo@stanford.edu, Mohsen Bayati, Erica Plambeck

This work looks at the effect of wait time information provision on patients' pain, waiting experience, and related behavior in the Emergency Department (ED). Three different wait time information (1.no information, 2. single wait time estimate, 3. range wai time estimation) are looked using a field experiment in an ED, where we survey patients' waiting experience while waiting under each treatment. A lab-experiment involving pain, waiting, perceived waiting, wait time information and related behavior is carried as well to study this phenomenon.

2 - On the Non-equivalence of Trade-ins and Upgrades in the Presence of Framing Effect: Experimental Evidence and Implications for Theory

Mahdi Mahmoudzadeh, Georgia Institute of Technology, Scheller College of Business, Atlanta, GA 30308, United States

Manufacturers of durable goods often buy back older versions of their products from customers to induce them to switch to improved versions. Classical model has long ignored the framing of these buyback schemes, i.e., trade-ins or upgrades, and its relevance for consumer behavior and theory. Using reference-point shift mechanism, through controlled experiments we find that the alternative frames are not isomorphic and that they shift customers' reference points. We then use the experimental findings to extend a reference-dependence version of the classical model of trade-ins and upgrades and show that the behavioral extension modifies predictions of the classical model in line with reality.

3 - Enterprise Social Media Platform Design and White Collar Productivity

Samer Charbaji, PhD Student, University of Michigan Ross School of Business, Ann Arbor, MI, United States, charbaji@umich.edu, Stephen Leider, Roman Kapuscinski

Enterprise social media platforms (ESMPs) have been widely adopted by companies to promote help between employees, with mixed success. We experimentally study the effect of different ESMP designs on employee helping behavior and performance. Participants are assigned real effort tasks and have access to a platform allowing them to request and give help. Our treatments add design features to promote help: aggregate and individual information on helping, and symbolic rewards for achieving helping goals. We show that symbolic rewards for achieving goals yields the most help and the best participant performance, whereas helping information has little effect on helping behavior or performance.

4 - On Mechanisms with a Fairness-concerned Supplier: Theory and Experiments

Wanshan Zhu, Tsinghua university, Beijing, China, zhuws@mail.tsinghua.edu.cn, Zewu Jiang, Yang Zhang, Zhao Xiaobo, Jinxing Xie

Behavioral factors such as fairness affect the decisions and performance of partners in a supply chain; they need to be accounted for in mechanism design. We study the optimal nonlinear and linear mechanisms for the retailer and find both mechanisms has its merits under different conditions due to behaviors.

■ WB72

S- Columbia

Joint Session ISS/Practice Curated: Field Experiment Research at the Intersection of IS, OM and Marketing

Sponsored: Information Systems

Sponsored Session

Chair: Tianshu Sun, University of Southern California, Los Angeles, CA, 90089, United States

1 - Identifying Subgroups with Enhanced Peer Influence: A Large-scale Randomized Controlled Trials in Social Advertising

Shan Huang, Massachusetts Institute of Technology, Cambridge, MA, 02142, United States, Tong Wang, Haojun Wu

Peer influence is of central importance in social science. The goal of this paper is to identify subgroups where peer influence exerts enhanced effect on users' responses to social advertisements. Our model characterizes such a subgroup using a set of interpretable rules, constructed from information regarding a user (susceptibility), his/her friend (influence), and their relationship. We present a Bayesian framework for learning a rule set. The Bayesian model consists of a prior to control the size and shape of a rule set and a Bayesian logistic regression to characterize interactions of features, treatment and subgroup membership. We also develop an efficient inference method for learning a MAP model. For this study, we partnered with a world leading mobile social-network platform, WeChat, and conducted a large-scale randomized con- trolled field experiment on WeChat Moments (i.e., newsfeed), on more than 28 million users across 99 ads. We compared our model with state-of-the-art baseline methods on this data set. Our model showed competitive performance and demonstrated high robust- ness for different types of product ads. This is the first paper on a machine learning model to identify subgroups with enhanced peer influence in social advertisements across different product categories. This study provides important insights for advertisers to increase the effectiveness of peer influence in propagating new products of different categories in social networks.

2 - Sooner or Later? Learning from Delivery Speed Information

Ruomeng Cui, Emory University, 1935 Ridgemont Lane, Decatur, GA, 30033, United States, Tianshu Sun

Online retailers who sell physical products need to inform customers how fast an order can be delivered. On one hand, an aggressive (faster) delivery estimate could meet more demand and thus may increase current sales. On the other hand, however, it may also raise the likelihood of customers experiencing a loss in time due to a longer than expected wait, which might hurt future sales. Collaborating with an online store selling custom products, we exploit its shipping rule changes intending to identify the effect of delivery information. We leverage the exogenous policy change and use a difference-in-difference approach to examine whether and how consumers respond to the delivery information.

3 - Effects of Online-offline Channel Integration on E-healthcare Providers: Evidence from a Natural Experiment

Haonan Yin, Beijing Institute of Technology, Beijing, China, Ni (Nina) Huang, Zhijun Yan

Leveraging a natural experiment on a prominent online health community website in China, we empirically investigate the impact of online-offline channel integration on the healthcare providers' online and offline demand, as well as their reputation. Employing multiple identification strategies, our results show several interesting findings: i) Online-offline integration, on average, leads to increases in the e-healthcare provider's online demand and decreases in the provider's offline demand; ii) Online-offline integration, on average, results in increased reputation for the e-healthcare providers; iii) The providers' medical specialty (chronical vs. non-chronical) moderates the main effects, such that the providers who specialize in treating chronical diseases experienced stronger increases in both online demand, and offline demand, and greater elevation in reputation; iv) The healthcare provider's status (professional vs. novice) moderates the main effects, such that the providers with high professional titles experienced stronger increases in online demand, weaker decreases in offline demand, and greater elevation in reputation. This work helps to answer the research questions on the online-offline channel integration as an antecedent to the healthcare providers' performance, which offers valuable design implications for the online healthcare communities.

4 - Connecting Customers and Merchants Offline: Experimental Evidence from the Commercialization of Last-mile Pickup Stations at Alibaba

Brian Rongqing Han, University of Southern California, Los Angeles, CA, 90017, United States, rongqinh@marshall.usc.edu, Tianshu Sun, Leon Zhu, Lixia Wu

Many e-commerce platforms have established extensive networks of last-mile stations as their logistics infrastructure. In this study, we investigate how this last-mile infrastructure may serve as an offline platform for commercial activities (e.g., free sample distribution) to connect customers and merchants. In collaboration with Alibaba, we design two large-scale experimental studies and provide the first evidence on how platforms can leverage the walk-in traffic (organic interaction) and prompt nearby customers through online intervention (induced interactions) to improve customers' online engagement with the merchants and offline utilization of logistics infrastructure.

■ WB73

S- Boren

Skills We Are Hiring Now

Emerging Topic: INFORMS Section on Practice

Emerging Topic Session

Chair: Carrie Beam, University of Arkansas, Walnut Creek, CA, 94596, United States

Moderator

William Christian, 1214 Somerset Road, Severn, MD, 21144, United States

Panelists

- William Christian, Severn, MD, 21144, United States
- Chongli Daniel Chen, Massachusetts Institute of Technology, Seattle, WA, 98118, United States
- Rajeev Namboothiri, GE Global Research, John F. Welch Technology Centre, Bangalore, 560066, India, rajeev.namboothiri@ge.com

■ WB74

S- Capitol Hill

Auctions and Remanufacturing

Contributed Session

Chair: Zhaohui Geng, University of Pittsburgh, Pittsburgh, PA, 15213, United States

1 - A Logistics Service Quality Based Auction Mechanism for Procuring Last Mile Delivery Capacity

Guangxin Gao, Assistant Professor, Nanjing University of Aeronautics & Astronautics, Nanjing, China, gxgao@nuaa.edu.cn, Zhiping Fan

The increasing demand for last mile delivery has created a challenge for urban consolidation centers (UCCs). Due to the UCC's limited capacity, it has to procure carriers' spare capacity to fulfill the last mile delivery needs. In the procurement, many potential risks may result in low logistics service quality (LSQ). Thus, we propose an LSQ based auction mechanism for the procurement, in which we introduce the LSQ in last mile delivery and then we construct an auction model to ensure UCC's incentive and award business to the carriers delivering high LSQ. The numerical study shows that the proposed mechanism is an efficient procurement tool for the UCC by total cost saving and effective use of resources.

2 - On Finding Stable and Efficient Solutions for Assigning Students to Project Centers with Cohort Considerations

Hoda Atef Yekta, Youngstown State University, Youngstown, OH, United States, hatefyekta@ysu.edu, Andrew C. Trapp, Pitchaya Wiratchotisatian

Global projects are a cornerstone of the project-based curriculum at Worcester Polytechnic Institute (WPI). Recent increases in applications have caused the manual process of placing students (nearly 1,000) into international project centers (nearly 50) to become increasingly complex. We propose an optimization-based mechanism that matches students to project centers by considering student preferences, center capacities and priorities over student skills. Our model finds stable and efficient solutions, and seeks to satisfy multiple cohort characteristic (like gender and major combinations) for project centers.

3 - Evaluating Profitability of Remanufacturing Operations

Akshay Mutha, University of Vermont, Burlington, VT, United States, Saurabh Bansal, V. Daniel R. Guide

We compare different methods for evaluating profitability of remanufacturing operations. We show the application of our model to current industry practices.

4 - Reverse Engineering System: Tolerance Estimation and Analysis for Remanufacturing

Zhaohui Geng, Doctoral Student, University of Pittsburgh, Pittsburgh, PA, United States, zhg17@pitt.edu, Bopaya Bidanda

Reverse engineering (RE) technique possesses dual roles in the RE system (RES): by definition, it can be used to extract the design and tolerancing information from physical parts; as a manufacturing process, it possesses variable nature. We first propose an algorithm to extract 'empirical' tolerance information by analyzing the small batch of products. Firstly, the variational behavior of the calculated mean volumetric data is analyzed from multiple scanning data cloud. Next, a GD&T standard is included in the analysis to classify data cloud into tolerancing database. By deducting the tolerance from RE, the remaining tolerance region can be used for the process design of future remanufacturing.

■ WB75

S- Metropolitan Ballroom A

Flash Session VII

Flash Session

Chair: Soemon Takakuwa, Chuo University

1 - Outsource (some of) What You Do Best, To Better Outsource the Rest

Sébastien Mitraille, Toulouse Business School, Toulouse, France, s.mitraille@tbs-education.fr, Christophe Bernard

When choosing to externalize differentiated operations to a supplier whose cost is unknown and lower on a subset of the production process, an efficient (respectively inefficient) manufacturer minimizes its expected total cost by over (resp. under)-outsourcing to this supplier. When facing its preferred type is likely enough, an efficient manufacturer may choose to unbundle the most costly operations and internalize the worst; a one-size-fits-all contract can be more profitable. When under (resp. over)-outsourcing occurs, the ex-ante total expected cost is more (resp. less) sensitive to the manufacturer's internal cost than at first best.

2 - Predicting Degree Completion Using Neural Networks

Tatiana A. Cardona, PhD Candidate, Missouri University of Science and Technology, Rolla, MO, United States, tacvhd@umsystem.edu, Elizabeth A. Cudney

Increasing retention and completion rates in STEM majors for higher education in the United States, is one of the objectives of the U.S. Department of Education. In these terms, the analysis of student data is vital to determine the factors that influence degree completion rates, providing an opportunity to investigate and improve intentional student advising. To this end, this paper presents the application of neural networks (NN) using a database comprised of 283 entries with 14 variables collected from a community college in the Midwest. The model performance for prediction of completion was over 95 percent. The model also presents a rank of factors that influence the student completion rates.

3 - Intermediary Agri-service Providers with Co-production: The Impact of Farm Size on Performance

Omkar D. Palsule-Desai, Indian Institute of Management-Indore, Indore, India, omkardpd@iimidr.ac.in, Yini Gao, Teo Chung Piaw

A challenge for an intermediary agri-service provider is achieving an appropriate balance between yield improving efforts and assured prices to be offered to the farmers. We develop a noncooperative game theoretic model that captures farming yield of traditional and high-value farm-produce, the trader's commission rates in the open-market, and the supply chain players' farming and effort-cost functions. We describe the economics associated with co-production, gather farmer level data from a firm, and validate observed behavior of players in the real-world setting.

4 - Product Return Predict and Precisely Purchase Freight Insurance for Online Buyers

Bingnan Yang, Huazhong University of Science and Technology, Wuhan, China, yangbingnan@hust.edu.cn, Xianhao Xu

One of the most controversial issues in after-sales service is who should assume the return freight insurance. Now most of merchants choose to buy freight insurance for their buyers to ease dispute and improve customer satisfaction, especially in special festival promotion. Hence, in order to increase the return on investment (ROI), identifying which buyer will return the goods and only buying freight insurance for them is very significant. So, we propose an auto purchase freight insurance system (FIS) to help merchants purchase freight insurance scientifically for their buyers. Our system has been proved to reduce the total cost of merchants effectively.

5 - Production Control in Conjunction with Real-time Simulation Using IoT

Soemon Takakuwa, Chuo University, 6-22-5, Ono-cho, Tokyo, 486 0926, Japan, takakuwa@indsys.chuo-u.ac.jp, Wenhe Yang, Kohtaroh Yoshida, Yifei Tan

Real-time simulation is proposed to see the current status of a physical manufacturing system especially by applying IoT. A framework for integrating management systems such as the ERP/MES system with associated simulation models is presented to perform more effective production control in the IoT/Industry 4.0 environment.

6 - Optimization Model for Work Shifts Generation in the Operation of a Massive Transport System

David Alvarez Martinez, Universidad de Los Andes, Bogota, Colombia, d.alvarezm@uniandes.edu.co, Daniel Esteban Cortes, Luis Miguel Escobar-Falcón, Kenny Cardenas Parra, Rubén Bolaños, Cesar Marín

The formation of work shifts is a problem in a Bus Rapid Transit System, due to costs of hiring drivers to carry out the routes. The generation of shifts consists of putting together work schedules blocks, to cover the operation of the routes designated by the transport system (Megabus). To solve this problem, a two-phase solution methodology was proposed, based on a Column Generation Algorithm that combines the work blocks, minimizing the number of shifts. The proposed methodology was compared using real world instances, presented by Megabus. The proposed methodology reaches feasible solutions in reasonable computing times and outperforms all the proposed solutions of the skilled practitioners.

7 - Optimization Model for Work Shifts Generation in the Operation of a Massive Transport System

David Alvarez, Universidad de Los Andes, Bogota, Colombia, Daniel Esteban Cortes, Luis Miguel Escobar-Falcón, Kenny Cardenas Parra, Rubén Bolaños, Cesar Marín

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■ WB76

S- Metropolitan Ballroom B

Operations Management VI

Contributed Session

Chair: Xiaoyun Xiong, China University of Petroleum, Qingdao, 266580, China

1 - Application of AHP with Multi-item Inventory Management Using Part Period Algorithm

Hossein Jamshidi, Alabama A&M University, Normal, AL, United States, hossein.jamshidi@aamu.edu

This empirical study deals with integration of Analytical Hierarchy Process (AHP) with multi Item Inventory Management using Part-Period Algorithm. this study considers the variables of Lot-sizing rules, sequencing, demand pattern, coefficient of variations, and change over cost. AHP is used to pick a sequencing rule and performance criteria. The proposed study presents a methodology to provide tools in the form of multiple tables to assist production managers to utilize work centers in a Group Technology environment in a manner to minimize employee and machine idleness and in making decisions on order quantity size.

2 - A New Data Driven Debiasing Method for Behavioral Newsvendor Problem

Byeong-Yun Chang, Ajou University, Suwon, Korea, Republic of, bychang@ajou.ac.kr, Quan Ha

In many empirical studies on behavioral newsvendor problem, managers' decisions are found to be suboptimal due to biases in their decision-making behaviors. This study developed a data-driven method to support newsvendors to improve their decision performance. The method provides the order quantity that empirically maximized expected profit (EMEP quantity), computed from historical data as a supporting statistical reference for manager to adjust their next order decisions. The study provides a mathematical evidence of the method's efficiency in an ideal condition and statistical evidence on its potentials in improving newsvendor's order quantity over time.

3 - Research on the Behavior of Sewage Enterprises under Sudden Environmental Inspection Incidents

Dan Luo, Tongji University, Shanghai,China, China, 1550724@tongji.edu.cn

Environmental inspection is an environmental governance system with Chinese Characteristics. Central environmental protection inspectorate has formed an organic system with local governments, sewage enterprises, pollution control enterprises, third-party detection agencies, the public, the media and the ecological environment. The various stakeholders in this system usually choose their own behavior from their own interests. Based on Emergency Management and Planned Behavior Theory, the behavior of sewage enterprises under sudden environmental inspection incidents is studied according to the top-down thinking.

4 - An Exact Branch-and-Price Algorithm for Multitasking Scheduling on Unrelated Parallel Machines

Xiaoyun Xiong, China University of Petroleum, Tsingtao, China, xiongxy618@163.com, peng zhou

We consider the multitasking scheduling problem on unrelated parallel machines to minimize the total weighted completion time, the processing of a selected job on a machine may be interrupted by other jobs scheduled on the same machine that are available but unfinished. To solve this problem, we propose an exact branch-and-price algorithm, where the master problem at each search node is solved by a in-out column generation. We use a hybrid strategy combining a genetic algorithm and an exact dynamic programming algorithm to solve the pricing subproblems approximately and exactly, respectively. Using randomly generated data, we evaluate the performance of the proposed solution approach.

■ WB77

S- Fremont

Innovation/Entrepreneurship

Contributed Session

Chair: Sameer Borwankar, Purdue University, West Lafayette, IN, 47906, United States

1 - Blockchain: Trust, Gender and Risk

Juan Andrei Villarroel, Professor of Innovation and Entrepreneurship, School of Management Fribourg, Fribourg, Switzerland, andrei.villarroel@hefr.ch

This research investigates how blockchain technology —or more technically, distributed-ledger technology (DLT)— enables 'trust' in the context of the news media. A body of literature posits the critical role of traditional news media organizations due to "trust" considerations. However, an emergent literature posits that DLT brings a technological alternative to "trust", which extends it beyond the realm of traditional institutions. Our survey of 2'200 respondents in Switzerland, unveils the actual "trust" that individuals put onto DLT, by contrast to traditional news media —international and local. The results should have important managerial and policy implications.

2 - Price Discrimination in Crowdfunding: An Investigation of Coupons

Xiahua Wei, Assistant Professor, University of Washington, Bothell, WA, United States, Weijia You, Yong Tan

Offering coupons is emerging as a new strategy for fundraisers to attract backers in crowdfunding. Using project-level panel data from a large crowdfunding platform, we analyze how coupons contribute to the amount of funds raised and the probability of funding success. We find that the backing options with coupons captivate more backers, without crowding out backers of other options where coupons are unavailable. This positive impact decreases with the coupon duration. Further, only regular backers, rather than wholesale or lottery backers, are drawn by coupons. These findings provide new insights into how a traditional marketing strategy of price discrimination creates value for crowdfunding.

3 - Technology Innovation under Quality Uncertainty

Yiwei Wang, University of California-Irvine, Irvine, CA, United States, willwangyiwei@gmail.com

Firms constantly invest on improving the product quality with innovative technology. However, the innovative technology's performance could be inconsistent from time to time. This paper studies how should the firm set the level of its quality improvement under deterministic technology, uncertain technology, or offer the existing product with no improvement at all. These conditions are affected by a number of driving forces, such as level of uncertainty and cost structures.

4 - A Theory of Value Appropriation of Patent Trolls

Mingtao Xu, Purdue university, West Lafayette, IN, United States, mingtaoxu@purdue.edu

We develop a model of patent monetization. We compare the practicing method, where value appropriation occurs in the product market, and the litigating method, where value appropriation occurs via the threat of legal action. We show that differences in both the technical strength and the exclusionary strength of the patent lead to differences in the value that firms can appropriate from monetization. The profit of practicing is convex in exclusionary strength, while that of litigating is convex. The model provides a theory of non-practicing entities (NPE) by explaining how firms with different monetization methods value patents differently and how valuations affect patent acquisitions.

5 - Effect of Digital Merger & Acquisition on Innovation

Sameer Borwankar, Purdue University, West Lafayette, IN, United States, sborwank@purdue.edu

In 2018, nearly one-third of companies logging M&A activity described themselves as traditional companies acquiring digital companies or assets. This type of M&A activity differs from the traditional acquisition which is focused on increasing the revenue or decreasing the costs through synergies in the short to medium duration. The literature on the traditional merger and acquisition suggests that the innovation level of the post-integration entity is lower than that of the parent firm. In this research, we empirically study the digital merger and acquisition and its effect on the innovation of the post-integration entity.

■ WB78

S- Greenwood

Big Data II

Contributed Session

Chair: Floris Herrema, EUROCONTROL, Prins Hendrikweg 23, Noordwijk, 2202EC, Netherlands

1 - Application of Machine Learning Algorithms for Identification of Entrepreneurial Digital Profiles Based on Information from a Big Russian Social Network

Margarita Gladkova, Graduate School of Management, St. Petersburg University, St. Petersburg, Russian Federation, gladkova@gsom.spbu.ru, Evgenii Gilenko

The goal of this unique study is to create detailed portraits of entrepreneurs operating on a digital platform. The data for analysis is provided by the biggest Russian social network - VKontakte where more than 400 000 businesses are registered. The modern methods of statistical analysis and machine learning are used to classify the businesses and build their profiles.

2 - Stroke-risk Stratification Scheme an EHR Based Predictive Analytics Study

Rupesh K. Agrawal, Research Assistant, Oklahoma State University, Tulsa, OK, United States, rupesh.agrawal@okstate.edu, Farooq Junaid, Dursun Delen, Bruce A. Benjamin, Matt Wilkett

Stroke-Risk Stratification scheme (RSS) is the gold standard for calculating the stroke risk of a patient with Atrial Fibrillation (AF). Stroke-RSS is based on prevalence numbers and does not include significant factors, e.g. Comorbidities: obstructive sleep apnea, COPD: clinical markers, e.g., cholesterol levels. The goal of this study is to scrutinize significant factors extracted from a national patient data repository, to improve Stroke-RSS using predictive analytics tools.

3 - Data Capacity and Statistical Quality Considerations in Support of Healthcare Modeling Efforts

Steven B. Cohen, Vive President, RTI International, Washington, DC, United States, scohen@rti.org

To complement current state assessments of health care, policymakers depend on model-based future state estimates under alternative assumptions subject to greater levels of uncertainty beyond sampling and nonsampling error. The integration of national survey data with content derived from big data sources and nonprobability based samples is gaining traction to inform these efforts. Comparable standards of data quality and statistical integrity for these modeling and simulation efforts are needed to convey levels of uncertainty in results. This presentation focuses on these sources of uncertainty in resultant estimates and methodologies to better quantify their error bounds.

4 - An Incremental Learning Risk Model: A Data Streaming Approach

Sandeep Goyal, Associate Professor, University of Louisville, Louisville, KY, United States, Donghui Shi, Jozef Zurada, Jeff Guan, Waldemar Karwowski

Changes in situations modifies the input data thereby inducing changes in risk model. Batch processing techniques such as regression are unable to keep up with such changes. We present a novel approach that uses data streaming to develop a risk model which accounts for data drifts. The goal of this risk model is to determine which combinations of human-social-infrastructure development projects are most effective in reducing risks. A data stream approach using three data stream algorithms is compared to batch-based algorithms—namely, the newer machine learning algorithms as well as the traditional regression approach. The results show that the data stream methods models risk better.

5 - Analyzing Large-scale Human Mobility Patterns for Disaster Management and Planning

Boyeong Hong, New York University, Brooklyn, NY, United States, Constantine E. Kontokosta, Bartosz Bonczak, Arpit Gupta

This paper presents a novel analytic approach, integrating big data, geospatial analytics, and machine learning, to understand individual- and neighborhood-level evacuation and recovery patterns in Houston, Texas before, during, and after Hurricane Harvey in August 2017. Using a detailed dataset of geolocations from more than 400,000 unique mobile devices, we develop unsupervised clustering and statistical models to identify socio-spatial disparities in evacuation behaviors. Our findings support data-driven and hyperlocal emergency management strategies, such as targeted outreach to at-risk populations and more efficient and fair resource allocation to aid vulnerable communities.

6 - APOC Big Data Study at Heathrow Airport

Floris Herrema, EUROCONTROL, Noordwijk, Netherlands, floris.herrema@eurocontrol.int

Improving airport performance is at the heart of the SESAR's Airport Operations Centre (APOC) solution. In this study, we review APOC roles and responsibilities, identify the key APOC processes that could be enhanced by data-driven predictions and machine learning techniques, and demonstrate a case study of how shared data and advanced analytics can be used to make predictions of passengers' connection times. In the case study, a regression tree model is fitted to a large training set with 3.7 million passenger records. This predictive model is applied to generate forecasts of each passenger's connection time and the passenger flows during an eight-hour live trial.

■ WB80

S- Issaquah B

Simulation and Optimization II

Contributed Session

Chair: Lu Zheng, Southeast University, Nanjing, 210096, China

1 - Optimal Design in Industrial Seeding Operations: A Simulation-based Optimization Approach

Jingyuan Feng, Dalian University of Technology, Dalian, China, Nan Kong, Xiangpei Hu

Industrial seeding is important in the modern agriculture industry for its high production intensity and controllable production time. It is a complex decision making process, along which order acceptance, backlog production, and environment control decisions should be made intelligently for revenue maximization. In this paper, we propose a hybrid event-based and time-based simulation model to evaluate the performance of the industry seeding system, and PSO combined with OCBA optimization approach to search the promising decision-making policies under a simulation budget constraint. It provides a novel applications to the agriculture production system using simulation optimization.

2 - Reliability-based Design Optimization of Airport Concrete Pavement

Ramin Giahi, Graduate Research Assistant, Iowa State University, Ames, IA, United States, rgiahi@iastate.edu, Adel Rezaei-Tarahomi, Cameron MacKenzie, Halil Ceylan, Kim Sunghwan, Kasthurirangan Gopalakrishnan

Artificial neural network alongside a design optimization framework is proposed to find the optimal design of the airfield rigid pavement. This optimal design should consider different values of the uncertain parameters. The design optimization model is solved considering different reliability levels and design lives for the airfield rigid pavement.

3 - Data Mining and Discrete-event Simulation for Improving Flight Operations at a Focal Airport

Canser Bilir, Istanbul S. Zaim University, Istanbul, Turkey, canser.bilir@izu.edu.tr, Laurence Douglas Smith

Investments in airport infrastructure (e.g., new runways and terminal modifications) cost billions of dollars. Analytical tools are needed to assess how changes in airport infrastructure, supporting resources, and operational practice may affect scheduled airline service, air cargo operations and general aviation flights that operate at commercial airports. In this study, we describe a unique blend of statistical modeling, discrete-event simulation and analytical decision support for planning of airport infrastructure, airline flight operations and airside operating practice.

4 - Simulation Optimization Using Stochastic Kriging with Robust Statistics

Linhan Ouyang, Nanjing University of Aeronautics and Astronautics, Nanjing, China, ouyang@nuaa.edu.cn, Chanseok Park

This paper provides some theoretical results on the predictive and optimization performance of stochastic kriging and proposes a robust stochastic kriging which is less sensitive to normal departure and data contamination by using robust location and scale estimations. Statistical properties of the robust estimators are briefly analyzed and the performances of the proposed methods are compared through numerical examples of different features. The comparison results show that the proposed robust stochastic kriging with the robust estimations is quite efficient no matter whether the standard assumptions hold or not.

5 - The Algorithm Which Creates the Complete Paths of Rescue Drones

Taihei Miyama, Waseda University, Tokyo, Japan, 1003taihei@gmail.com, Takashi Hasuike

In recent years, many natural disasters have occurred in Japan. In such a situation, quick rescue activities using UAVs such as drones are drawing attention.To doing rescue activities using UAVs, we should determine the flying paths of rescue drones. These drones' paths should cover the whole target area, and these paths are called Complete Path.In this study, we assume rescue activities which using some drones after disasters. Then propose the algorithm which creates the complete paths of rescue drones and verify the efficiency of the flight paths through simulation.

6 - Evolutionary Game Analysis of Information Quality under Public Participation

Lu Zheng, Southeast University, Nanjing, China, zzlu0918@hotmail.com

Please check the mobile app for this abstract.

■ WB81

S- Kirkland

Sustainability II

Contributed Session

Chair: Yanqi Zeng, Huazhong University of Science and Technology, Luoyu Road 1037, Hongshan district, Wuhan, China

1 - A Supply Chain Model for 3D Printed, Orthopedic Implants

Margaret Golz, North Carolina State University, Raleigh, NC, United States, mgolz@ncsu.edu, Richard A. Wysk, Russell Edward King, Ola L. Harrysson

Personalized orthopedic medicine has previously been reserved for specialty cases but, with the advent of additive manufacturing, volume production of personalized orthopedic implants is highly anticipated. The objective of this research is to develop the supply chain model of orthopedic implants produced with electron beam melting technology and identify the effect of uncertainty in parameter estimation. The method of this analysis is to characterize key performance indices for different control variables and experimental parameter variations in order to better understand the effect of uncertainty and relationships of the manufacturing process.

2 - Supply Chain Efficiency and Performance under Sustainability Initiatives

Yabing Zhao, Assistant Professor, San Francisco State University, San Francisco, CA, United States, ybzhao@sfsu.edu, Zhuang Qian

While sustainability has gained momentum in today's global economy, it's still in the early stage of a decades-long trend. The main objective of this research is to understand firms' reporting and implementation of sustainability initiatives and their impact on firm and supply chain's future efficiency and performance through empirical analysis.

3 - A Hybrid Framework to Identify and Prioritize the Most Important Supply Chain Enablers to Improve Sustainability

Sajad Ebrahimi, North Dakota State University, Fargo, ND, United States, Joseph Szmerekovsky

Businesses currently face pressure from both government regulations and customers' expectations in reaching sustainable supply chains, and that forces them to implement sustainable practices. To adopt sustainable supply chain management (SSCM), industries need to identify influential enablers. This study aims to identify influential enablers for SSCM by using fuzzy Delphi method and then apply interpretive structural modeling to find the relationships between the recommended enablers to find impressionability and effectiveness. Finally, considering the relations between the enablers, the authors use a fuzzy analytical network process, to find the most important SSCM enablers.

4 - Customer Concentration and Supplier's Corporate Social Performance

Jia Gao, Shanghai Jiaotong University, Shanghai, China, jia.z.gao@gmail.com, Ying Rong, Zhao xiaoping

Although there are extensive studies about Corporate Social Performance (CSP), our understanding of CSP in supply chain context is limited. In this study, we first identify the correlation between customer concentration and supplier's CSP. Then we investigate several key factors to help to explain this correlation.

5 - The Effect of Corporate Equity Structure on Innovation Investment: Evidence from China

Yanqi Zeng, Huazhong University of Science and Technology, Wuhan, China, yanqizeng66@163.com

This paper explores the impact of corporate equity structure on innovation investment and studies the moderating effect of environmental uncertainty. With the data of 1417 observations of Chinese listed companies in 2015-2017, empirical results show that the higher the concentration of equity, the less invest in innovation, and firms with high shareholding ratio of executives tend to invest more in innovation, and the moderating effect of environmental uncertainty is also different.

■ WB82

S- Leschi

Joint Session ENRE/Env/Practice Curated: Methods and Results for the Costs and Environmental Impacts of Ride-Hailing

Sponsored: Energy, Natural Res & the Environment/Environment & Sustainability

Sponsored Session

Chair: Matthew Bruchon, Pittsburgh, PA, 15206, United States

Co-Chair: Jeremy J Michalek, Carnegie Mellon University, Pittsburgh, PA, 15213, United States

1 - Sustainable Urban Mobility with Transit Centric On-demand Services

Samitha Samaranayake, Cornell University, School of Civil & Environmental Engineering, 220 Hollister Hall, Ithaca, NY, 14853, United States, samitha@alum.mit.edu

The rapid expansion of on-demand ride-hailing services has changed the transportation landscape in many cities worldwide. While these services are a valuable alternative travel mode, as evident by their popularity, there are many questions regarding their scalability, efficiency, equity and negative externalities (e.g. congestion, pollution etc.). One way to mitigate some of these concerns is to consider high-capacity ride-pooling services, where many passengers share a vehicle simultaneously, and better integration with public transit. This talk will present a general framework for solving problems of this type at large-scale.

2 - Socially Adoptable Energy-efficient Mobility Systems

Andreas Malikopoulos, University of Delaware, Newark, DE, United States, andreas@udel.edu

The purpose of a transportation system is not mobility but rather accessibility to goods, services, and activities. Mobility is only an unintended outcome of our accessibility needs. A mobility system involves the interactions of three heterogeneous features that constitute a sociotechnical system: 1) transportation systems and modes, e.g., connected and automated vehicles, public transit, and shared mobility, 2) social behavior of drivers and travelers interacting with these systems, and 3) institutional behavior of organized units such as regulators. The talk will discuss how we can develop an energy-efficient mobility system from a sociotechnical systems perspective.

3 - Optimizing Ride-Hailing Fleet Electrification to Minimize Costs and Emissions

Matthew B. Bruchon, Carnegie Mellon, Pittsburgh, PA, 15206, United States, mbruchon@andrew.cmu.edu, Jeremy J. Michalek, Inês Azevedo

With higher capital costs and lower operation costs, electric vehicles may be competitive for high-use applications, including transportation network companies (TNCs) like Uber and Lyft. Electric vehicles may also help reduce air emissions. This study co-optimizes TNC vehicle purchases (battery, hybrid, or conventional powertrains), routing, and charger scheduling to minimize private costs in a mixed-integer model aided by heuristics. We then assess the impact of emissions pricing by considering how the optimal fleet changes when emissions externalities are added to the objective function.

4 - Vehicle Minimum Occupancy Standards for TNCs to Encouraging Ride Pooling

Paul Leiby, Oak Ridge National Laboratory, Oak Ridge, TN, United States, Jonathan Rubin

Ride pooling (shared rides) and increased vehicle occupancy have been identified as key requirements for achieving the full benefits of new mobility systems, including transportation network companies (TNCs), vehicle automation and connectivity. We distinguish "ride pooling" from "vehicle sharing" (or ride hailing) in which vehicles are used sequentially by different users, each charged per ride or per time period. As mobility options expand, incentives for ride pooling are necessary to limit congestion, energy use, and emissions since several studies have shown that simply sharing vehicles will not significantly reduce, and could increase, vehicle kilometers travelled (VKT). This is especially a concern with connected autonomous vehicles where the convenience and lower cost per kilometer are expected to increase vehicle travel demand. The goal is to reduce congestion and energy use while still providing for high levels of mobility. To incentivize TNC fleet operators to increase vehicle occupancy (ride pooling), we propose using flexible Minimum Occupancy STandards (MOSTs). MOSTs are performance standards that would require TNCs to collectively achieve a minimum ride-weighted occupancy level across their fleets. MOSTs would deter empty vehicle kilometers and encourage ride pooling. We specify an approach for incentivizing higher ridership in Transportation Network Company (ridehail/ridepool) vehicles through an average vehicle occupancy standard and first evaluate it analytically. We utilize available data on TNC travel, geographic analysis of ride pooling potential, and economic behavioral assumptions to benchmark an illustrative numerical model, and develop initial insights on the efficiency of pooling standards or incentives, as measured by mobility and economic impacts.

5 - Analysis of Future Mobility On-Demand Systems in Global Urban Typologies

Jimi B. Oke, Massachusetts Institute of Technology, Cambridge, MA, 02139, United States, oke@mit.edu, Arun Prakash Akkinepally, Youssef M. Aboutaleb, Siyu Chen, Yifei Xie, Carlos L. Azevedo, Pericles C. Zegras, Joseph Ferreira, Moshe E. Ben-Akiva

With global urbanization expected to reach 60% by 2050, innovative solutions must be devised to meet growing demand. We thus propose a systemic approach to analyze the impacts of mobility policies on future outcomes. Building on prior discovery of 12 global urban typologies, we generate 3 high-fidelity, typology-representative prototype cities. We then simulate these cities via SimMobility, analyzing the impacts of automated mobility on-demand (AMoD) strategies using via demand, congestion, supply and energy outcomes. Our results provide insights into how AMoD can be sustainably harnessed in transit-oriented and auto-dependent cities.

■ WB83

S- Medina

Stochastic and Robust Optimization in Energy Systems

Sponsored: Energy, Natural Res & the Environment/Electricity

Sponsored Session

Chair: Andy Sun, Georgia Institute of Technology, Atlanta, GA, 30332-0205, United States

1 - Impacts of Topology Control on Zonal Markets

Quentin Lété, CORE, UCL, Louvain la Neuve, Belgium, quentin.lete@uclouvain.be, Anthony Papavasiliou

We present a two-stage model of zonal electricity markets with day-ahead market clearing and real-time redispatch that accounts for transmission line switching at both stages and N-1 robustness. We show how the day-ahead problem with switching can be formulated as an adaptive robust optimization problem with mixed integer recourse that we solve using a nested column-and-constraint generation algorithm. We apply these models on a realistic instance of the Central Western Europe system and comment on the impacts of both proactive and reactive transmission switching on the operating costs of the system.

2 - Stochastic Dual Dynamic Programming Algorithm for Nonconvex Multistage Optimization Problems

Shixuan Zhang, Georgia Institute of Technology, Atlanta, GA, 30318, United States, szhang483@gatech.edu, Andy Sun

Nonconvex multistage optimization problems can often be decomposed into relatively tractable subproblems via dynamic programming. We use the generalized conjugacy of nonconvex functions to propose an iterative approximation scheme for the cost-to-go functions. This approximation scheme is shown to be both valid and tight for a wide range of nonconvex problems. We establish the convergence rate results for the deterministic case and show the application in the stochastic dual dynamic programming algorithms.

3 - Applying Multi-stage Stochastic Programming to Investment Planning for Energy Systems.

Anthony Downward, University of Auckland, Auckland CBD, Auckland, 1024, New Zealand, a.downward@auckland.ac.nz, Andy Philpott

Energy systems around the world are adapting to new policies around emissions, this is leading to the closure of many existing plant, and the increased utilization of renewable generation sources. In this work we present a multistage stochastic integer programming framework, developed in Julia, which determines an optimal investment policy, given a scenario tree for demand growth. The individual stage problem for this is a 5-year operational policy for an electricity sector, given the endogenous investment decisions. We apply this model using the New Zealand electricity market as a case study.

4 - Distributionally Robust Optimization with Conditional Ambiguity Sets for Power System Planning

Alexander Velloso, Pontifical Catholic University of Rio de Janeiro, Rio de Janeiro, Brazil, David Pozo, Alexander Street

We propose an extension of the traditional distributionally robust optimization (DRO) framework to consider multiple ambiguities sets simultaneously. This framework can conciliate multi-scale (long and short) uncertainties for long-term decision-making, like in power systems planning. The multi-ambiguity-set DRO problem results in an infinite-dimensional problem. A new enhanced-column-and-constraint generation decomposition approach is proposed with an additional Dantzig-Wolfe step that allows a better representation of the DRO recourse function and tight lower and upper bounds. Numerical experiments for planning power systems corroborate the effectiveness of the method.

■ WB84

S- Ravenna A

Electric Vehicle-based Mobility and the Power Grid

Sponsored: Energy, Natural Res & the Environment/Energy

Sponsored Session

Chair: Kevin Melendez, University of South Florida, University of South Florida, Tampa, FL, 33613, United States

Co-Chair: Tapas K. Das, University of South Florida, Tampa, FL, 33620-5350, United States

1 - Multi-objective Electric Vehicle Facility Management: Exact Method for Network Design and Dynamic Pricing Scheme with User Decisions

Leila Hajibabai, North Carolina State University, Department of Civil Engineering, 2433 Computer Science, Raleigh, NC, 11794, United States, lhajiba@ncsu.edu, Amir Mirheli

This study develops an exact method for electric vehicle infrastructure design and management under the impacts of user-specific decisions. The objective is to determine the optimal number, location, and capacity of charging facilities in the transportation network with optimal demand-responsive pricing scheme. The problem is formulated as a bi-level optimization program that minimizes the total facility deployment and operation costs under user-equilibrium flows. The proposed solution technique solves the bi-level problem to exact optimality by generating theoretical lower- and upper-bounds to the proposed problem.

2 - Scenarios of Transportation Electrification

Matteo Muratori, NREL, Golden, CO, 80401, United States, matteo.muratori@nrel.gov

Transportation is currently the least-diversified energy demand sector, with over 90% of global transportation energy use coming from petroleum product. After over a century of petroleum dominance, however, many leading experts anticipate major electrification trends that could disrupt the transportation energy demand landscape. This talk describes scenarios of future transportation electrification and their impact on bulk power systems.

3 - Electric Vehicles Equilibrium Model that Considers Charging Queue and Complementary Traffic

Nurit Oliker, PhD, Universite de Montreal (DIRO), Montreal, QC, Canada, nurit.oliker@umontreal.ca, Miguel F. Anjos, Margarida Carvalho, Emma Frejinger, Bernard Gendron

We present an assignment model for electric vehicle (EVs) that considers both queue delay in charging stations and flow dependent travel times in the network, given the complete traffic. EVs feasible paths are found given the limited travel range and the layout of fast charging stations infrastructure. This is a user equilibrium model that considers travel, charging and queuing times in the path choice modelling of both EVs and the complementary traffic. The charging stations capacity is represented as an M/M/k queuing system. The charging time is a function of the flow and the charging quantity, considering several vehicle and driver classes. Numerical examples present the model properties.

4 - On the Integration, Location, and Operations of Smart Hubs for Shared Autonomous Electric Vehicles

Kevin A. Melendez, University of South Florida, Tampa, FL, 33613, United States, kmelendez7@mail.usf.edu, Tapas K. Das, Changhyun Kwon

Companies providing ride sharing service in cities are expected to adopt a new business model partially switching from cars owned by individuals to SAEVs leased from companies. Switching to SAEVs for ride sharing will only be possible with the availability of smart hubs to support SAEV fleet operation for efficient charging and discharging of batteries. This work presents a comprehensive methodology to operate a large fleet of SAEVS providing ride services while supporting the power grid. Our methodology considers both transportation and power systems constraints and uncertainties, including but not limited to: dynamic prices, customers arrivals, DA commitments, and RT balancing.

■ WB85

S- Ravenna B

Integrated Energy Systems: Challenges & Opportunities

Sponsored: Energy, Natural Res & the Environment/Energy

Sponsored Session

Chair: Dharik Mallapragada, Massachusetts Institute of Technology, MA, United States

Co-Chair: Ajit Gopalakrishnan, Air Liquide, Newark, DE, 19702, United States

1 - A Log-Barrier Newton-CG Method for Bound Constrained Optimization with Complexity Guarantees

Mark O'Malley, Senior Research Fellow, NREL, Boulder, CO, United States, Stepehn J. Wright

We describe an algorithm based on a logarithmic barrier function, Newton's method, and linear conjugate gradients, that obtains an approximate minimizer of a smooth function over the nonnegative orthant. We develop a bound on the complexity of the approach, stated in terms of the required accuracy and the cost of a single gradient evaluation of the objective function and/or a matrix-vector multiplication involving the Hessian of the objective. The approach can be implemented without explicit calculation or storage of the Hessian.

2 - Representing Short-Term Uncertainties in Capacity Expansion Planning Using a Rolling-Horizon Operation Model

Espen Flo Bødal, Department of Electric Power Engineering, Norwegian University of Science and Technology, Trondheim, Norway, espen.bodal@ntnu.no, Audun Botterud, Magnus Korpås

Flexible resources such as batteries and demand-side management technologies are needed to handle future large shares of variable renewable power. Wind and solar power introduce more short-term uncertainty that have to be considered when making investment decisions as it significantly impacts the value of flexible resources. In this work we present a method for using duals from a rolling horizon operational model, with wind power uncertainty and market representations, to represent power system operation in an investment problem. The method is based on benders decomposition and special considerations are made due to the nature of the rolling horizon operational framework.

3 - Value of Energy Storage in Low-carbon Grids with High Shares of Wind and Solar Penetration

Dharik S. Mallapragada, MIT Energy Initiative, Massachusetts Institute of Technology, Cambridge, MA, United States, dharik@mit.edu, Nestor A. Sepulveda, Jesse D. Jenkins

The rapid rise in variable renewable energy (VRE) generation in the power sector has prompted interest in studying long-term system impacts of their adoption and the role for energy storage. This study uses a high temporal resolution capacity expansion model (CEM) to assess the system value of energy storage in providing multiple grid services under different grid and technology scenarios. The analysis will discuss the sensitivity of storage value to: 1) regional differences in load and VRE resource availability (e.g. U.S. Northeast vs. Texas), 2) the penetration of storage, VRE generation and 3) provision of one or more grid services (e.g. reserves, transmission deferral).

4 - Optimal Battery Sizing and Location for Offshore Wind Energy

Mehdi Jafari, Postdoctoral Associate, Massachusetts Institute of Technology (MIT), Cambridge, MA, United States, jafari@mit.edu, Audun Botterud, Apurba Sakti

With increased variable renewables in power systems, the challenge of grid integration emerges. One promising solution is using energy storage system. The traditional approach of modeling batteries for grid applications is to include fixed efficiencies or maximum power while these parameters are dependent on power and SOC. Also, batteries degrade over time. We developed a model of offshore wind-battery system, while modeling the power limit and efficiency as a function of output power and SOC and accounting for degradation. The resulting model is in the form of mixed integer linear programming (MILP). We study different configurations of system on multiple li-ion chemistries in energy arbitrage.

■ WB86

S- Ravenna C

E Business/Commerce I

Contributed Session

Chair: Ling Ding, Xi'an Jiaotong University, Xi'an, 710049, China

1 - When Does the Platform Tell You the Truth? Optimal Design of Persuasion Policy in the Two-sided Market

Andy Tao LI, School of Economics and Management, Tsinghua University, beijing, China, lit3.14@sem.tsinghua.edu.cn, Jie Zheng

We analyze the information announcement strategy for the C2C Service platform, whereas platform provides not only a less profitable standard service with stochastic stock-out risk, but also a more profitable premier service with no stock-out risk. While the expected stock-out rate is commonly known, customers do not observe the availability of the standard service when they choose between two services. Thus, their decision can be influenced by the service availability information announced by platform. We show that designing a state-contingent probabilistic disclosure policy and hence involves lying under some conditions, will be profitable and solve the optimal disclosure strategy.

2 - Optimal Referral Reward Program in a Freemium Model

Wei Geng, Southwest Jiaotong University, Chengdu, China, wgeng@swjtu.edu.cn

Freemium is a prevalent business model for selling information goods or services. In this model, firms offer basic core functions for free and sell premium functions to high-end consumers. Referral reward programs are commonly observed when those firms are trying to harness the power of social networks. We consider a firm in a monopoly market and consumers embedded in a social network, and demonstrate the optimal referral reward program for the firm. Price of the premium version, reward mechanism and reward size are considered.

3 - Perceived Risk and Its Impact on Intention to Use Mobile Banking in a Newly Emerging Country

Long Pham, University of Louisiana at Monroe, Monroe, LA, United States, pham@ulm.edu

We present research investigating if customer perceived risk in the mobile banking setting is a second-order construct comprising of first-order constructs - component risk factors. We examine which component risk factors contribute the most to customer perceived risk and the relationship between customer perceived risk and intention to use mobile banking in a newly emerging country. We analyze survey data from 403 mobile banking customers, using the structural equation modelling technique to present new insights.

4 - An Empirical Study of Promotion Effects on Store Sales

mengmeng wang, Shanghai Jiao Tong University, Shanghai, China, wangmengmeng1@sjtu.edu.cn

Mobile payment prevails in China and various promotions launched by mobile payment platform facilitate the adoption of mobile payment. This paper investigates the impacts of mobile payment promotions on store sales in the two-sided market. Our empirical analysis is based on the sales data of 40 chain stores within 5 months. Tencent launched a payment promotion, such that users can receive a random price cut . We use the difference in differences (DID) method to analyze the effect of the promotions. The estimated results show that the mobile payment promotion has a positive impact on store sales on the day of promotion but has no impact on long-term overall sales.

5 - Research on the Algorithm of E-commerce Product Name Recognition Based on the gcForest Model

Jing Ma, Nanjing University of Aeronautics and Astronautics, Nanjing, China, majing5525@126.com, Xiaofeng Li, Chi Li, Xiaoyu Guo, Bo He

Aiming at the demand of automatic catalogue identification for E-commerce commodities, this paper puts forward the problem of product name recognition for the first time in the field of e-commerce. The supervised machine learning algorithm based on the gcForest model is used to recognize the product name from the short text of the e-commerce product descriptions. Experiments show that, for 800 different products 100,000 records of product description, the accuracy of the algorithm is 0.91 and the recall rate is 0.93. Experiments prove that the algorithm is reasonable, effective and practical.

6 - Subscribing Before or Paying After? Should the Live Platform Use Pay-what-you-want Pricing?

Ling Ding, Xi'an Jiaotong University, Xi'an, China, lingding5-c@my.cityu.edu.hk, Xiuwu Liao

Subscriptions and advertising have been the main source of profit for video sites, but for live platforms, subscriptions have dominated for a long period. In recent years, live broadcast platforms have increasingly paid attention to Pay-What-You-Want Pricing. Hence which pricing strategy should be optimal for the platform? A single or mixed pricing strategy? We develop an analytical model and collect data from a live broadcast platform to study how the platform chooses the optimal pricing strategy, consumer surplus and social welfare.

Wednesday, 1:30PM - 3:00PM

■ WC01

CC- Room 201

Social Media Mining: Techniques and Applications

Sponsored: Data Mining

Sponsored Session

Chair: Jasmina Tacheva

1 - Engaging Team Formation Problem for Maximizing Online Forum Activity

Alexander Nikolaev, Associate Professor, University at Buffalo, Buffalo, NY, 14260-2050, United States, anikolae@buffalo.edu, Rahul Swamy, Alexander Semenov

Online Health Forums (OHFs) such as WebMD and MedHelp provide structured support to users and visitors by fostering a community of users that actively engage in the forum. In order to assess the quality of forum communication, it is important to quantify and compute how “engaging” the users are. In this research, we use a co-operative game theory-based approach to quantify engagement, by extracting the temporal and network structure of an online forum. A case study using real-world data compares the results from using this approach with traditional, network centrality-based approaches.

2 - It's All about Who You Know: Exploring Weak Ties on LinkedIn

Natalie Simpson, University at Buffalo, Buffalo, NY, 14260-4000, United States, nsimpson@buffalo.edu

Collaboration is an essential part of humanitarian operations, since the synergies it creates are associated with better humanitarian outcomes at all phases of the emergency management cycle. We aim to investigate whether the primacy of collaboration in disaster management translates into more diverse social networks maintained by emergency management professionals compared to those exhibited by experts in operations and supply chain management not involved in disaster mitigation. Our approach is based on a combination of machine learning and social network analysis of data from the social network platform LinkedIn.

3 - Identifying Opioid Dependency of Twitter Users Through Personality Traits: A Machine Learning Approach

Anton Ivanov, University at Illinois, 326 Jacobs Management Center, Urbana, IL, 14260, United States

To address challenges in opioid surveillance and advance knowledge of the role of individual differences in opioid abuse, we compare the personality profiles of Twitter users who self-disclosed the fact of being addicted to opioids to non-users using the wide spectrum five-factor model. To do so, we apply a range of machine learning techniques. Our results provide (1) conceptual clarifications on the difference in personality traits between opioid addicts and non-users, and (2) suggestive evidence that multilayer perceptron performs acceptably to identify Twitter users with opioid dependency.

4 - Human Centered NLP with User-Factor Adaptation

Youngseo Son, Stony Brook University, 100 Nicolls Road, Stony Brook, NY, 11794, United States, yson@cs.stonybrook.edu, H. Andrew Schwartz, Veronica Lynn, Vivek Kulkarni, Niranjan Balasubramanian

We pose the general task of user-factor adaptation — adapting supervised learning models to user factors inferred from a background of their language, reflecting the idea that a piece of text should be understood within the context of the user that wrote it. We introduce a continuous adaptation technique, suited for real-valued user factors that are common in social science and bringing us closer to personalized NLP, adapting to each user uniquely. We apply this technique with known user factors including age, gender, and personality traits, as well as latent factors, evaluating over five social media tasks: POS tagging, PP-attachment, sentiment analysis, sarcasm detection, and stance detection.

5 - Helping Relief Organizations Help Through ML

Jasmina Tacheva, SUN Y. at Buffalo, Buffalo, NY, 14210, United States, zhasmina@buffalo.edu, Natalie Simpson

While the analysis of user-generated data for resource allocation decision-making during a disaster has been studied across different scientific fields, there is a dearth of research on how humanitarian organizations can use such data to design and implement more effective communication campaigns in order to assemble resources rather than solely distribute them. We propose a machine learning model which can be used both in real time and retroactively to parse humanitarian aid messages in social media for the purpose of identifying digital volunteers whose efforts may directly aid relief organizations in their mission to help communities in need.

■ WC02

CC- Room 202

Advances in Statistical/Machine Learning for Business

Sponsored: Data Mining

Sponsored Session

Chair: Artem Prokhorov

1 - Causal Inference with Bayesian Additive Trees and Subclassification

Marcel Scharth, The University of Sydney, University of Sydney, Australia

We develop a Bayesian semi-parametric framework for the estimation of the conditional average treatment effect (CATE) function in observational and experimental studies. We flexibly model the response surface using a Bayesian Additive Regression Tree (BART) specification that adaptively combines joint and separate estimation of conditional expectations for the treatment or control groups. Treatment effect estimators based on regression methods can be severely biased in the presence of pronounced confounding. We address this problem by integrating our regression approach into a new subclassification scheme based on the propensity score.

2 - Lasso-type Regularization with Nonparametric Bernstein Copula and its Application in Financial Markets

Aixi Zhang, University of Sydney, Sydney, Australia, aixi.zhang@sydney.edu.au, Artem Prokhorov, Peter Radchenko

Modeling the dependence structure is a key aspect of data mining and statistical learning. Constraints of shape and misspecification of parametric models for complex financial data necessitate a flexible model. We propose a penalized nonparametric Bernstein copula approach. It employs the Bernstein polynomial sieves to tackle the difficulties in optimization over infinite dimensional space and utilizes an adapted LASSO penalty to reduce the risk of overfitting and efficiency loss. The weights of the penalty are set as reciprocals of the empirical copula in order to impose sparsity. We demonstrate merits of our proposed model compared with its counterparts through Monte-Carlo simulations.

3 - Feature-based Time Series Forecast Model Combination

Pablo Montero-Manso, Monash University, Melbourne, Australia

We discuss a new methodology for forecast model combination which can be used for selecting the best single model, the best subset or an accurate averaging of a set of models. A meta-learning model uses features (e.g. autocorrelations, spectral entropy) of a series to produce the weights used in the combination. The meta-model is trained on a large collection of time series with known future values by optimizing a new objective function. Empirical results on 100000 time series show good forecasting accuracy (achieved second position in the recent M4 forecasting competition) and robustness against model miss specification. The method can easily be adapted for different forecasting error measures.

4 - Application of Machine Learning Algorithms for Identification of Entrepreneurial Digital Profiles Based on Information from a Big Russian Social Network

Margarita Gladkova, Graduate School of Management, St. Petersburg University, St. Petersburg, Russian Federation, gladkova@gsom.spbu.ru, Evgenii Gilenko

The goal of this unique study is to create detailed portraits of entrepreneurs operating on a digital platform. The data for analysis is provided by the biggest Russian social network - VKontakte where more than 400 000 businesses are registered. The modern methods of statistical analysis and machine learning are used to classify the businesses and build their profiles.

■ WC03

CC- Room 203

Data Driven Supply Chain

Sponsored: Data Mining

Sponsored Session

Chair: Mohammad Pirhooshyaran

1 - Reinforcement Learning for Decision-making in Multi-echelon Supply Chains

Mohammad Pirhooshyaran, Lehigh University, Bethlehem, PA, 18015, United States, Mohammadreza Nazari, Lawrence V. Snyder

We discuss reinforcement learning (RL) methods for making decisions in multi-echelon supply chains. Many production-distribution structures have no known optimal inventory policies or closed-form cost functions. The fact that the optimal policies depend on the network structure and parameter values further complicates the analysis. We consider non-serial inventory networks with stochastic demands, in which each stage must make inventory decisions based on incomplete information about the supply chain as a whole. We model this problem using a multi-agent RL framework.

2 - Digital Platforms in Service Operations

Jie Sheng, University of Bristol, Bristol, United Kingdom, jie.sheng@bristol.ac.uk

Relying on information and communication technologies, organisations are increasingly digitalizing service operations to improve customer experience and business productivity. Digital platforms such as social media and mobile apps become growingly important touchpoints for firms to manage. We discuss how businesses can effectively engage in digital platforms and harness massive data generated in the platforms to improve operational practices.

3 - Digital Twinning for Healthcare Logistic in Enhancing Efficiency and Effectiveness: Case Study in Singapore

Sunil Tiwari, Research Fellow, National University of Singapore, Singapore, Singapore, tlist@nus.edu.sg

Most of the healthcare institutions in Singapore realize the inevitability of manpower challenges especially at the bottom of the workforce pyramid and in order to come up with this; they have to adopt more process-based technologies, particularly in robotics and automation. In the hospital of tomorrow, RPA will be a part of IoT to assist the new mission. This study explores productivity improvement opportunities through RPA usage, application of Data Analytics, and implementation of optimization within the HI. The transportation system within the hospital, dispatching rule of the lifts and robots, are optimized through extensive simulation.

■ WC04

CC- Room 204

Uncertainty Quantification:? AI-based? Modeling and Decision-making Under? Uncertainty

Sponsored: Data Mining

Sponsored Session

Chair: Aven Samareh

1 - Dirichlet Process Mixture Model-based Quality Control with Uncertainty in Advanced Manufacturing Processes

Jia (Peter) Liu, Auburn University, Auburn, AL, United States, Zhenyu (James) Kong

Nonlinear and nonstationary process dynamics in advanced manufacturing (e.g., batch production, process state shifting) incur challenges of achieving stable process states and reliable product quality. Dirichlet process mixture model, a nonparametric Bayesian model, can adaptively model latent components and capture their changes from the generated complex non-Gaussian sensor data. Therefore, quality control algorithms based on the Dirichlet process mixture model possess flexibility in modeling and mitigate the uncertainty in decision making. They outperform traditional statistical process control methods in several case studies of advanced manufacturing processes.

2 - Deep Learning and Uncertainty Quantification for Climate Resilience

Thomas Vandal, Research Scientist, NASA Ames, Moffett Field, CA, United States, vandal@beari.org

Modeling and monitoring of earth's processes through physical models and satellite observations at high resolutions is crucial for ensuring society's ability to adapt to climate change. Deep learning (DL) has been shown to be a valuable tool for generating high resolution data, emulating physical models, and detecting weather patterns which can then be used to inform stakeholders and decision makers. However, both the data and model parameters contain substantial uncertainties that may alter users' decisions. In this work we present two DL applications on high-resolution climate and satellite datasets using Bayesian neural networks to generate well calibrated uncertainty estimates.

3 - A Deep Reinforcement Learning Approach for Real-time Sensor-driven Decision Making

Erotokritos Skordilis, University of Miami, Coral Gables, FL, United States, sge12@miami.edu, Ramin Moghaddas

Complex industrial equipment requires robust real-time control policies. Deep reinforcement learning (DRL) is capable of deriving such policies due to its capacity to address highly complex control and decision making problems. DRL describes interactions between an agent and its environment through actions that maximize a cumulative reward. The environment is described with a set of states that denote system degradation and can be inferred using particle filtering (PF). We propose a decision making method that combines DRL and PF for real-time control regarding degrading systems under partial information. Numerical results are provided for a NASA C-MAPSS turbofan engine degradation dataset.

■ WC05

CC- Room 205

Data Mining VII

Contributed Session

Chair: Reyhaneh Bijari, Iowa State University

1 - How New Technologies are Transforming Medicine

Krzysztof “Krys” Cios, Virginia Commonwealth University, Richmond, VA, United States, kcios@vcu.edu

We will focus on technologies that are transforming the practice of medicine. Majority of those technologies generate huge amounts of heterogeneous digital data that humans can neither integrate nor analyze. It is thus technology that must be used to mine in these data to find new information and present it to health care practitioners in an understandable way, best visual. Some of the disruptive technologies we will talk about include wearable devices, artificial intelligence and machine learning, image understanding, and social networks. We will end by describing some deployments of new technologies in terms of case studies.

2 - Tagging Medical IoT Devices with Token Data

Yue (Richard) Xie, VP of Data Science and Application, Cylera, New York, NY, United States, richardxy@gmail.com

We have seen exponential growth rate of medical IoT devices being utilized in nationwide healthcare institutes The network security of those IoT devices has become a great concern for all the stakeholders. One of the first challenges in providing cybersecurity to industrial IoT devices is to accurately and timely identify the devices on a network. This talk introduces the approach to applying natural language processing (NLP) methods to analyze and transform textual tokens transmitted between devices to construct a classification model for tagging the devices.

3 - Understanding the Vulnerable Community Through Social Network Analytics and Text Mining

Xin Tian, Assistant Professor, Kennesaw State University, Marietta, GA, United States, xtian2@kennesaw.edu, Wu He, QIng Wen, Weidong Zhang

This study investigates the vulnerable groups from social media using social network analysis and text mining techniques. Increasing patients and their family are publicly expressing their thoughts and feelings about health care issues and challenges facing them on the Internet. Guided by the social exchange theory, this study revealed some evidence that indicates and classifies the benefits and concerns of cancer patients and caregivers in the U.S and China. This research demonstrates how cancer patients and their families use social media to exchange social support with others who experience similar challenges.

4 - Optimal Imputation and Outlier Detection

Maxime Amram, Research Scientist, Interpretable AI, Cambridge, MA, United States, maxime@interpretable.ai, Dimitris Bertsimas, Ying Zhuo

Data quality issues such as missing values and outliers remain a key roadblock to deriving value from big data and machine learning deployments. We developed Optimal Imputation, a novel framework to impute missing data by jointly optimizing the values and the model (KNN, SVM, or decision-tree based models) on the data. In large-scale synthetic and real data experiments, we show Optimal Imputation produces the best overall imputation in the majority of all datasets benchmarked against state-of-the-art methods. We also discuss how this approach can be used to detect outliers.

5 - Training Data Selection in Plant Breeding

Reyhaneh Bijari, Graduate Research Assistant, Iowa State University, Ames, IA, United States, rbijari@iastate.edu, Sigurdur Olafsson

In plant breeding, a decision to advance an experimental plant variety to the next year of testing must be made on very limited data. However, some experimental varieties behave in a similar manner and have similar genotype-by-environment (GxE) interactions. In this paper, an efficient training data selection algorithm is performed to find the best varieties which help describe the true distribution of yield for a given target variety to inform the decision making. This methodology helps to improve the model performance and to determine training observations which result in the best model. Additionally, we obtain insights into the GxE interactions for the target and selected varieties.

■ WC07

CC- Room 210

Optimization in Clustering and Applications

Sponsored: Data Mining

Sponsored Session

Chair: Gokce Kahvecioglu

1 - A Graph-theoretic Dissimilarity Measure for Flow Field Classification

Eli Olinick, Southern Methodist University, Dept Eng Mgmt Info and Systems, Po Box 750123, Dallas, TX, 75275-0123, United States, olinick@lyle.smu.edu, Paul Krueger, Michael Hahsler, Sheila Williams, Mohammadreza Zharfa

We propose a generalization of the well-known Gabriel graph to represent key features in repeated patterns of vortices in fluids (flow fields) generated by various means, including swimming animals. The representation is designed for clustering and classification of flow fields; it is sensitive to the topological and geometric structure of the field, but relatively insensitive to small changes in vortex location. We present a suite of binary integer programs to measure dissimilarity between graphs constructed with our model for input as distances to a hierarchical clustering algorithm. Experiments with computer-generated flows demonstrate the high accuracy of the resulting classification.

2 - Fluxcom:A Local Strategy for Community Detection in Dynamic Networks

Rodrigo Francisquini, Universidade Federal de São Paulo, São José dos Campos, Brazil, francisquini.r@gmail.com, Mariá C. Nascimento

Several complex systems can be represented by dynamic graphs that change over time. Community detection strategies are commonly used to analyze and understand the structure of these networks. Although the literature of community detection in static networks is vast, there are a few strategies that can effectively find communities in dynamic networks. This study presents a strategy to detect communities in dynamic networks capable of locally correcting communities through modularity maximization. In computational experiments with real-world biological and social networks, the introduced strategy showed excellent results with low computational cost.

3 - Interpretable Clustering: An Optimization Approach

Agni Orfanoudaki, Massachusetts Institute of Technology, Cambridge, MA, 02142, United States, agniorf@mit.edu, Dimitris Bertsimas, Holly Mika Wiberg

We present a new unsupervised learning method that leverages optimization techniques to generate interpretable tree-based clustering models. Utilizing a flexible framework, our algorithm approximates the globally optimal solution leading to high-quality partitions of the feature space. Our method can optimize for various clustering internal validation metrics and naturally determines the optimal number of clusters. It achieves comparable or superior performance to K-means on both synthetic and real-world datasets while offering significantly higher interpretability.

4 - An Objective for Hierarchical Clustering in Euclidean Space and its Connection to Bisecting K-means

Yuyan Wang, Carnegie Mellon University, Pittsburgh, PA, United States, yuyanw@andrew.cmu.edu, Benjamin Moseley

Divisive algorithms are widely used to construct hierarchical clusterings, yet many currently used algorithms are not known to optimize a global objective function. This paper develops a new natural global objective for hierarchical clustering. The objective captures the criterion that has motivated the use of bisecting clustering algorithms: that two clusters separated at a level in the tree should contain points that are closer than points across clusters. This paper proves that iteratively adopting optimal k-means gives a constant approximation for the objective function proposed. This is the first paper to show optimal k-means optimizes a global objective over the entire tree.

5 - Parametric Bicriteria Clustering on a Graph

Gokce Kahvecioglu, PhD Student, Northwestern University, Evanston, IL, 60208, United States, gokcekahvecioglu2014@u.northwestern.edu, David Morton

Given an undirected graph with positive weights on the edges we study a parametric bicriteria graph clustering problem. We remove a subset of edges to break the graph into smaller pieces, i.e., connected components, or clusters. We seek to maximize the number of clusters while minimizing the weight of the removed edges. We identify nested solutions that lie on the concave envelopeof the efficient frontier, yielding a hierarchical family of clusters, in strongly polynomial time. We demonstrate the performance of our approach on a network dened by the schedule of football teams in the National Collegiate Athletic Association (NCAA), which has a known hierarchical structure.

■ WC08

CC- Room 211

Artificial Intelligence II

Contributed Session

Chair: Sam Ganzfried, Ganzfried Research, Miami Beach, FL, 33139, United States

1 - Optimizing Ensemble Weights and Hyperparameters for Machine Learning Models for Regression Problems

Guiping Hu, Iowa State University, Ames, IA, United States, gphu@iastate.edu, Mohsen Shah Hosseini

Ensembles are gaining more popularity among data scientists and researchers due to their superior performance. While different studies show the power of weighted ensembles, there is no systematic approach to find the best weights. A novel optimization approach for regression problems is proposed, that formulates the weights for each model. Besides, the effect of tuning hyperparameters on optimal ensembles is studied. Experiments on several data sets show the better performance of the suggested optimization model compared to both individual learners and unweighted average ensembles. Furthermore, it was shown that the best ensemble is not necessarily resulted from optimal hyperparameters.

2 - Efficient Retrieval System for Similar and Same-process Blueprint Images

Hisaya Miyao, Waseda university, Tokyo, Japan, orange.380138@toki.waseda.jp, Takashi Hasuike

When we make a product in somewhere like a factory, we often refer past blueprints which are similar to the blueprint of it. This is a CBIR(Content-Based Image Retrieval) problem but not simple one, because it is necessary that not only the blueprints are similar to original one but also they have same processes. In addition, it is desirable to retrieve blueprints efficiently, so we have to build a efficient image retrieval system that retrieve similar blueprints which have same processes as those of original one. In order to achieve this task, we build some various systems and compare them. We evaluate each systems from the points of view of similarity, accuracy and process time.

3 - Combining Artificial Intelligence and Blockchains: Identification of Use Cases and Business Value

Rajhans Mishra, Indian Institute of Management-Indore, Indore, India, rajhans111@gmail.com, Mukul Gupta

Artificial Intelligence and blockchains are two emerging technologies. Sectors as health, retail and banking are using AI. Blockchain has become popular as an enabling technology of Bitcoin. Primarily blockchain has provided a technology platform where encrypted data is stored and new blocks are added by the miners sequentially. These two technologies can be amalgamated to capture the value for various purposes including intellectual property rights for content, smart contract, etc. The paper explores the synergy between these two technologies for real use cases and business value.

4 - A Hidden Markov Models Approach to Predict Early Detection of Equipment Failure

Prince Agarwal, Indian Institute of Technology Kharagpur, IIT Kharagpur, Kharagpur, We, Kharagpur, 721302, India, princeagarwal12@gmail.com, Akhilesh Kumar, Saptarshi Das, Venkatesh Madyastha

There have been considerable advances in sensing instrumentation, hardware, signal processing algorithms, and internet technology infrastructure that have eventually paved the way for the long-envisioned concept of smart factories under the purview of Industry 4.0. To leverage the available system data, factories across the globe are embracing Predictive Maintenance in the era of Industry 4.0. In the current study, the objective is to identify the early failure of equipment and determine the remaining useful life. Towards this end, a Hidden Markov Model-based sequential clustering algorithm has been developed and tested on sensor signals of different components of an oil and gas Company.

5 - A Fuzzy Inferenced Based Approach to Feature Selection for Supervised Machine Learning Models

Wilkistar Otieno, University of Wisconsin - Milwaukee, Milwaukee, WI, United States, otieno@uwm.edu, Phillip LaCasse, Francisco Maturana

The big data environment enabled by smart manufacturing technology is such that many thousands of independent variables might be utilized as inputs for training applied machine learning models. This research provides an algorithmic approach to reducing the feature set through sequential filtration and quantifying the value associated with remaining features by means of a fuzzy inference system. The approach is validated in an applied case study in electronic assembly manufacture.

6 - Most Important Fundamental Rule of Poker Strategy

Sam Ganzfried, Ganzfried Research, 1504 Bay Road Apt 1706, Miami Beach, FL, 33139, United States, Max Chiswick

Poker is a large complex game of imperfect information, which has been singled out as a major AI challenge problem. Recently there has been a series of breakthroughs culminating in agents that have successfully defeated the strongest human players in two-player no-limit Texas hold 'em. The strongest agents are based on algorithms for approximating Nash equilibrium strategies, which are stored in massive binary files and unintelligible to humans. Using techniques from machine learning we have uncovered a new simple, fundamental rule of poker strategy that leads to a significant improvement in performance over the best prior rule and can also easily be applied by human players.

■ WC09

CC- Room 212

Healthcare Analytics

Sponsored: Artificial Intelligence

Sponsored Session

Chair: Xi Wang

1 - Medication Recommendations Using the Unsupervised Learning Algorithm

HU Yang, Central University of Finance and Economics, Beijing, China, hu.yang@cufe.edu.cn

The use of electronic health records that can bring valuable improvements to hospital practices by integrating patient information. In fact, the understanding of these data can help us recommend medication prescriptions to doctors and also prevent mistakes that may put patients' lives at risk. These problems can be modeled as a recommendation system that recommends the treatments based on drug-disease association, patient information and laboratory test information. In this study, we propose an unsupervised method to recommend medication prescriptions to the doctors.

2 - Using Analytical Modeling to Better Manage High-Risk Patients: A Population Health Approach

Hengwei Zhang, Claremont Graduate University, Claremont, CA, United States, hengwei.zhang@cgu.edu

Patient Risk stratification models are of great interests for both providers and payers in the U.S. healthcare system. As the top 5 percent of sickest patients count towards 50% of the total healthcare cost in 2016, the ability to identify these patients and design interventions have great potentials in reducing the healthcare cost and improving population health.This presentation focuses on the process of translating specific business questions to feasible predictive modeling questions, designing data pipelines that are capable of real-time scoring of new data, modeling, and results evaluation by using a real-world case study from a health plan in Southern California.

3 - A Matrix Decomposition Approach to Predicting Brugada Syndrome Based on ECG Data

Qingpeng Zhang, City University of Hong Kong, Kowloon, 12180, Hong Kong, qingpeng.zhang@cityu.edu.hk, Jiandong Zhou, Gary Tse

In this research, we present a nonnegative matrix factorization (NMF)-based approach to predicting the Brugada syndrome using ECG data. A set of ECG data in HK is used to evaluate the performance of the proposed approach. We show that the NMF-based approach outperforms traditional regression-based methods by capturing the complex interrelations among different risk factors.

■ WC10

CC- Room 213

Computational and Economic Considerations in Social Media Analytics

Sponsored: Social Media Analytics

Sponsored Session

Chair: Abhinav Maurya, Pittsburgh, PA, 15206, United States

1 - Optimal Transport Embeddings for understanding Occupations and Skills in the Labor Market

Abhinav Maurya, Carnegie Mellon University, Pittsburgh, PA, United States, ahmaurya@gmail.com

We propose a simple distribution-to-distribution optimal transport approach for (i) learning occupation and skill embeddings (OccupationEmbedding and SkillEmbedding) and (ii) identifying occupation-specific skills from these embeddings using OccupationSkillRanking with the goal of career-driven skill training for unemployed and underemployed workers. Our approach beats a number of baselines on metrics evaluating the quality of occupation-personalized skill recommendations, indicating that the Wasserstein metric can effectively model the distance between entity histograms such as those associated with multidisciplinary occupation histories and skill sets.

2 - Knowledge Sharing in the Sharing Economy – Evidence from Virtual Communities on Airbnb

Srikar Velichety, University of Memphis, Memphis, TN, 38111, United States, svlchety@memphis.edu

We investigate the drivers of knowledge sharing in host communities on sharing economy platforms using the literature on social capital and peer-effects. We also explain the impact of three different aspects of knowledge sharing on the performance of services in these platforms. Using a large multiyear dataset of posts collected from a virtual knowledge sharing community of hosts on AIRBNB, we estimate the impact of quantity, quality and diversity of knowledge sharing on the occupancy rates of properties. We also quantify the impact of peer-effects on knowledge sharing in these virtual communities.

3 - Effects of Subsidy Payment in Two-sided Market – The Case with Sponsored Data Programs

Jialin Song, University of Illinois at Urbana Champaign, Urbana, IL, 61801, United States, jsong83@illinois.edu, Qiong Wang

Mobile content access is a two-sided market where the network is the platform that connects providers and consumers of information products. As the platform operator, major Mobile Service Providers (MSPs) in the US have all introduced sponsored data programs that allow a Content Provider (CP) to pay for the use of network capacity by consumers to access its contents. Based on developing and analyzing a Stackelberg Game model, we discuss how the level of the subsidy payment affects profits of the MSP and the CP, and its impact on consumers' access to these programs and the resulting consumer surplus.

■ WC11

CC- Room 214

Ergodicity of Stochastic Systems

Sponsored: Applied Probability

Sponsored Session

Chair: Guodong Pang, Penn State University, University Park, PA, 16802, United States

1 - Exponential Ergodicity and Convergence for Generalized Reflected Brownian Motion

Wenpin Tang, UCLA, Los Angelos, CA, United States

In this talk, we discuss convergence analysis for a class of Brownian queues in tandem by establishing an exponential drift condition. A consequence is uniform exponential ergodicity for these multidimensional diffusions, including the O'Connell-Yor process. A list of open problems is also presented.

2 - Stationary Distributions and Convergence for M/m/1 Queues in Interactive Random Environment

Andrey Sarantsev, Assistant Professor, University of Nevada, Reno, Davidson Math & Science Center 314, Reno, NV, 89557, United States, asarantsev@unr.edu

We study a Markovian single-server queue in interactive random environments. The arrival and service rates of the queue depend on the environment, while the transition dynamics of the random environment depends on the queue length. We consider two types of Markov random environments: a pure jump process and a reflected jump-diffusion. In both cases, the joint dynamics is constructed so that the stationary distribution can be explicitly found in a product form. We derive an explicit estimate for exponential rate of convergence to stationarity via coupling.

3 - Convergence Rates to Stationarity for Reflected Brownian Motions

Sayan Banerjee, University of North Carolina, Chapel Hill, Chapel Hill, NC, United States, sayan@email.unc.edu, Amarjit Budhiraja

In this talk, we will explore methods to obtain rates of convergence to stationarity in L1-Wasserstein distance for obliquely reflected d-dimensional Brownian motion (RBM) in the nonnegative orthant that are explicit in the dimension and the system parameters. These processes emerge as heavy-traffic scaling limits of Jackson networks. The results are then applied to a class of RBMs considered by Blanchet and Chen (2016) and to rank-based diffusions including the Atlas model. In the first case we improve the relaxation time estimates of O (d4(log d)2) obtained in Blanchet and Chen (2016) to O ((log d)2). In the case of the standard Atlas model, the relaxation time is O (d6(log d)2).

4 - Stability of Certain Classes of Multi-pool Networks in the Halfin-Whitt Regime

Hassan Hmedi, University of Texas at Austin, Austin, TX, United States, hmedi@utexas.edu, Ari Arapostathis, Guodong Pang

We study ergodic properties of certain classes of multi-pool queueing networks having no abandonment. The system is heavily loaded in the Halfin-Whitt regime, and the scheduling policies are work-conserving and preemptive. We provide a unified approach by establishing Foster-Lyapunov equations for the limiting diffusion showing exponential ergodicity uniformly over all stationary Markov controls. We also employ these results in the study of the pre-limit diffusion-scaled queueing processes and define the notion of wide-sense jointly work conserving policies. We show that the diffusion-scaled processes are also exponentially ergodic, uniformly over all such policies.

5 - Stability of a Class of Markov Processes under Fast Regime Switching

Yi Zheng, The Pennsylvania State University, State College, PA, 16801, United States, yxz282@psu.edu, Ari Arapostathis, Guodong Pang

We study the stability of a class of Markov-modulated general birth-death processes under fast regime switching. We assume that the “averaged” fluid limit exists when a scale parameter is taken large, and the Markov-modulated process is centered and scaled. We provide a sufficient condition for the exponential ergodicity of the Markov-modulated process. We also establish Brownian steady-state approximation for the Markov-modulated process, and provide the convergence rate for the moments of diffusion-scaled processes to the steady-state moments. Some results of p-stability and sub-exponential ergodicity for the Markov-modulated process are also considered.

■ WC12

CC- Room 2A

Stochastic Dynamic Games in Economics

Sponsored: Applied Probability

Sponsored Session

Chair: Dharma Kwon, University of Illinois at U-C, Champaign, IL, 61820, United States

1 - Predatory Pricing under Uncertainty: Revisiting the Deep Pocket Argument

Maria Lavrutich, Tilburg University, Tilburg, Netherlands, Jacco Thijssen

We analyze a dynamic Cournot equilibrium in a continuous time stochastic game between capital constrained firms. Firms can choose both the production strategy and the dividend policy. When profits evolve stochastically, a negative demand shock can lead to bankruptcy. Firms then may have an incentive to start a price war. We focus on the link between predatory pricing and dividend policy and find that the presence of product market competition and the possibility of predation induces fewer dividend payouts. Predatory behavior only occurs when the prey is not distributing dividends. When both firms pay out dividends the equilibrium strategy is to be myopic and produce per-period Cournot quantities.

2 - Economically Valuable Exit from a Duopoly and the Feedback Effects Between First and Second Mover Advantages

Jan-Henrik Steg, Bielefeld University, Bielefeld, Germany, jsteg@uni-bielefeld.de, Jacco Thijssen

We analyse a dynamic model of a duopoly in which firms have an economically valuable option to exit by switching from one market to another. We construct a subgame-perfect equilibrium in Markovian mixed strategies and show that both preemption and attrition can occur along typical equilibrium paths. The presence of both effects implies different tradeoffs than in existing strategic real option models, and, accordingly, it changes the nature of the stopping problems to be solved. As a consequence, preemption and attrition cannot be analysed separately. In equilibrium, the threat of preemption gives firms an incentive to start a war of attrition sooner than they would without preemption.

3 - Pareto Optimality Versus Nash Equilibrium, Price of Anarchy Versus Price of Stability

Renyuan Xu, Oxford University, Oxford, United Kingdom, dorisxu1026@gmail.com, Xin Guo

Pareto optimality (PO) is an important concept in game theory to measure the global efficiency when players collaborate. In this talk, we start with the PO for a class of continuous-time stochastic games with finite number of players. To explicitly solve for a PO, we consider a central controller who coordinates the system and transform the problem into a sequence of Skorokhod problems. We then discuss the PO with infinity number of players, which leads the McKean-Vlasov dynamics. Another common criterion in game theory is the Nash equilibrium (NE) which captures the stability under competition. In the end, we compare the PO solution with the NE via price of stability and price of anarchy.

4 - Game of Variable Contributions to the Common Good under Uncertainty

Dharma Kwon, University of Illinois at U-C, Champaign, IL, 61820, United States, dhkwon@illinois.edu

We consider a stochastic game of contribution to the common good in which the players have continuous control over the degree of contribution, and we examine the gradualism arising from the free rider effect. Previously known examples of variable concession games in the literature yield equilibria characterized by singular control strategies without any delay of concession. We find that a variable contribution game with a single state variable possesses an equilibrium characterized by regular control strategies that result in a gradual concession. We also find that asymmetry between the players can mitigate the inefficiency caused by the gradualism.

■ WC13

CC- Room 2B

Advances in Machine Learning Models and Applications

Sponsored: Applied Probability

Sponsored Session

Chair: Floske Spieksma, Leiden University, Leiden, Netherlands

Chair: Michael N Katehakis, Rutgers University, Newark, NJ, 07010, United States

1 - New Reinforcement Learning Models and Algorithms for Healthcare Treatment Choices

Debopriya Ghosh, Rutgers University, New Brunswick, NJ, United States, Daniel Pirutinsky, Michael N. Katehakis, Odysseas Kanavetas, Spiros Papadimitriou

Starting with a large dataset of cancer patients, which contains patient level historical information on patient demographics, disease markers, diagnoses, previous treatments etc, we construct and analyze reinforcement learning models for patient centered treatment recommendations. The objective is to provide near optimal dynamic policies for treatment choices so as to maximize the probability of patient survival for a fixed time horizon.

2 - Inventory Management Enabled with Blockchain System

Jasmine (Aichih) Chang, New Jersey Institute of Technology, Newark, NJ, United States, Junmin Shi, Michael N. Katehakis

Blockchain has been widely embraced as a disruptive technology for inventory management. This study examines the Newsvendor model enabled with a blockchain system. It aims to shed light on how blockchain adoption impacts the optimal inventory decisions, illustrated with some selected demand types, such as Uniform and Normal distributions.

3 - Dynamic Inventory Control with Fixed Setup Costs and Unknown Discrete Demand Distribution

Mehdi Davoodi, Rutgers University, New Brunswick, NJ, United States, Michael N. Katehakis, Jian Yang

We study a dynamic inventory control problem involving fixed setup costs and random demand distributions. We depart from the traditional literature by allowing the stationary demand distribution to be largely unknown. We propose a policy that controls the pace at which a traditional (s,S)-computing algorithm is applied to the empirical distribution of the demand learned over time. It incurs a regret that would grow at an O(T^{1/2}(ln T)^{1/2})-sized rate.

4 - A Comparison Reinforcement Learning Algorithms

Daniel Pirutinsky, Rutgers University, New Brunswick, NJ, United States, Wesley Cowan, Michael N. Katehakis

In this talk we consider the basic reinforcement learning model dealing with adaptively controlling a Markov Decision Process (MDP) with unknown rewards and transition probabilities. We provide a survey of existing algorithms and numerically compare their performance.

■ WC14

CC- Room 302

Operations in On-Demand Platforms

Sponsored: Manufacturing & Service Oper Mgmt

Sponsored Session

Chair: Guangwen Kong, University of Minnesota, Minneapolis, MN, 55414, United States

1 - If You Love Your Agents, Set Them Freeish

Vasiliki Kostami, HEC Paris, Jouy-en-Josas, 78350, France, kostami@hec.fr

Flexibility is beneficial for matching supply with demand, but comes at a cost. In modern digital workplaces, users possess a spectrum of different skills associated with variable task preferences: Some are inclined to give up part of their payment to avoid unfavorable matches. The platform manager gains extra freedom in allocating tasks by possibly charging servers for a favorable assignment. We introduce an innovative mechanism for task assignment where agents are allowed some task discretion in exchange for a fee. We model different working environments and different servers' preferences and study how the preferences, the task cost, and the flexibility fee, affect the equilibrium assignment.

2 - Harnessing the Double-edged Sword via Routing: Information Provision on Ride-hailing Platforms

Dongyuan Zhan, University College London, School of Management, Gower Street, London, WC1E 6BT, United Kingdom, d.zhan@ucl.ac.uk, Leon Zhu, Zhixi Wan

We consider a ride-hailing platform that provides free information to taxi drivers. The platform broadcasts the origin and destination of the riders to idle drivers, who accept or ignore the request depending on the profitability. The first driver to accept the request serves the rider; if no driver accepts the request, the rider leaves. We show that such information provision is a double-edged sword: drivers may wait for more profitable riders via inefficient idling. When multiple drivers compete for the same request, how the platform breaks the tie affects the incentives of the drivers. We propose a routing policy that can align the incentives and achieve the first-best outcome for large systems.

3 - Two-sided Competition Between On-demand Service Platforms

Shining Wu, The Hong Kong Polytechnic University, LMS Dept., Hong Kong, 999077, Hong Kong, sn.wu@polyu.edu.hk, Shihong Xiao, Saif Benjaafar

On-demand service platforms compete for both agents and customers, and hence form a two-sided competition. In this paper, we perform a comprehensive study on the two-sided competition problem of two platforms with an in-depth analysis of its subgame. We separate our discussion into two cases where agents and customers may move sequentially or simultaneously. We find that these two settings yield different sets of subgame outcomes, and multiple subgame equilibria are possible. To obtain a unique prediction, we further examine some commonly used refinement rules and discuss their appropriateness. Lastly, we relate our findings to various possible competition outcomes that arise in practice.

4 - Surge Price or Subsidy? Information Sharing or Suggestion? A Behavioral Investigation of Workers' Relocation in On-demand Platforms.

Guangwen Kong, Temple University, Philadelphia, PA, Yinghao Zhang, Zhongzhong Jiang

We have witnessed a rapid rise of on-demand platforms, such as Uber, in the past few years. This research studies how workers respond to these policies and which policy (or policies) can effectively reduce supply-demand mismatch across regions in an on-demand platform. This research investigates workers' decisions from the behavioral perspective. We first analytically characterize the standard equilibrium predictions and then test them using a series of controlled laboratory experiments. We finally propose a behavioral model to explain the observed behavior in the lab.

■ WC15

CC- Room 303

Decision Analysis II

Contributed Session

Chair: Mona Khoddam, Arizona State University, School of Computing, Informatics, Tempe, AZ, 85281, United States

1 - An Optimal Policy for an Assignment of Police Patrols in the UMPD Precincts

Tongqing Chen, University of Minnesota-Twin Cities, Minneapolis, MN, United States, chen4823@umn.edu, Darin A. England

We developed a model applying the concepts of Markov Chain Process and Dynamic Programming to assign police officers to precincts of the local Police Department (UMPD). An optimal policy allocates officers for all the states to minimize the expected total number of crimes of the following shifts with considerations of both the short-term effects and the long-term effects. Our model can be applied to other police precinct areas to find optimal policies for police assignments.

2 - Realizing Context Effects by Ideal Point Estimation

Shotaro Kotani, Waseda University, Tokyo, Japan, phiokari@gmail.com, Takashi Hasuike

We suggest the model predicting human choice behavior.The characteristic of our model is to be able to represent the preference changing in some contexts.We respect the hypothesis that people generate the ideal choice when they make a decision from multiple alternatives.They then compare these alternatives with the ideal point and finally decide.We make the discrete choice model based on the hypothesis.To make a numerical experiment,we show the performance of our model.

3 - Mode of Improvement for Efficient Global Optimization of Expensive Stochastic Black Box Functions

Rajitha Meka, University of Texas-San Antonio, San Antonio, TX, United States, rajithameka14@gmail.com, Adel Alaeddini

In this study, we propose the mode of improvement (MI) algorithm for efficient optimization of stochastic black box functions. MI algorithm leverages the relationship between the expected value and standard deviation of the stochastic improvement in Bayesian optimization to dynamically balance exploration and exploitation to reduce the number of expensive evaluations. We validate the proposed algorithm using several simulated examples.

4 - Analysis of a Functional Response from a Mixture Experiment

Mona Khoddam, Arizona State University, Tempe, AZ, United States, mkhoddam@asu.edu

Mixture experiments are widely used in applications where the levels of the experimental factors are varying proportions of several chemical components that sum to a 100%.Previous and current work on the analysis of mixture data only involve single-response values.In this work,we discuss an application where the response from a mixture experiment is a series of data points collected over a continuum,known in the literature as functional data. This rheological response measure relates to a critical-to-customer attribute.Taking a single viscosity value at a fixed shear rate fails to capture the rheological differences among chemical formulations.

■ WC16

CC- Room 304

Capacity Management and Pricing for Services

Sponsored: Manufacturing & Service Oper. Mgmt/Service Operations

Sponsored Session

Chair: Serhan Ziya, University of North Carolina, Chapel Hill, NC, 27599, United States

Co-Chair: Eda Kemahlioglu Ziya, North Carolina State, Raleigh, NC, 27695-7229, United States

1 - Food Delivery Services for Restaurants: Friend or Foe?

Jianfu Wang, Nanyang Business School, Nanyang Technological University, Nanyang Avenue, Singapore, 639798, Singapore, Manlu Chen, Ming Hu

This paper studies the food delivery services using which customers can hire deliverymen to pick up food on behalf of them. To investigate the impact of food delivery service, we model a restaurant serving food to customers as a stylized single-server queue with two streams of customers. One stream is tech-savvy customers who can access the food delivery service. The other stream is walk-in customers who cannot access the food delivery service. We discover that when more customers have access to the food delivery service, both the society and the food delivery firm may be worse off. We propose remedies that may potentially create better coordination in a queue with food delivery service.

2 - On Designing a Socially-optimal Expedited Service when Customers Have Heterogeneous Usage Rates

Aditya Shetty, Simon Business School, University of Rochester, Rochester, NY, United States, aditya.Shetty@simon.rochester.edu, Ricky Roet-Green

We look at the problem of a congested system where a mandatory service is being provided. There are two variants of the service: a base version that customers can join at no cost and an expedited one that customers can join by paying a fixed one time fee. The service provider has a fixed total capacity and it must make a decision on how to split that capacity between the two services. Our goal is to find the socially optimal allocation while taking into account the equilibrium behavior of the customers.

3 - When Service Times Depend on Customers' Delays: A Solution to Two Empirical Challenges

Chenguang (Allen) Wu, Hong Kong University of Science and Technology, Academic Building, Clear Water Bay, 60208, Hong Kong, allenwu@ust.hk, Achal Bassamboo, Ohad Perry

Service times of customers often depend on the delays in queue, as was recently observed in restaurants, call centers and intensive care units. We propose two dependence mechanisms in service systems with customer abandonment, one exogenous and one endogenous. Identifying the source of dependence from observed data is hard because both the service times and the patience times are censored due to abandonment. Further, even if the dependence is known to be exogenous, there remains the difficult problem of fitting a joint distribution to the censored data. We address these two statistical challenges in the current paper by proving an equivalence relation between exogenous and endogenous dependencies.

4 - Pricing and Capacity Decisions for Shared Service Systems under Competition

Wei Gu, University of North Carolina-Chapel Hill, Carrboro, NC, 27510, United States, wei25@live.unc.edu, H. Sebastian Heese, Eda Kemahlioglu Ziya, Serhan Ziya

We consider service systems where customers' utility depends on price as well as their service experience, which in turn depends on how crowded the service environment is and with whom the service environment is shared. We investigate how two such systems make pricing and capacity decisions under competition.

■ WC17

CC- Room 305

Topics in Market Design

Sponsored: Manufacturing & Service Oper. Mgmt/Service Operations

Sponsored Session

Chair: Itai Ashlagi, Stanford University, Stanford, CA, 94305, United States

1 - Designing Informative Rating Systems: Evidence from an Online Labor Market

Nikhil Garg, Stanford University, Stanford, CA, 94025, United States, nkgarg@stanford.edu, Ramesh Johari

Platforms use rating systems to learn the quality of market participants. In practice these ratings are often highly inflated. We ask: 1), can rating systems better discriminate quality by altering answer labels and their numeric interpretations? 2), how should the platform make these choices in a principled manner? We analyze the results of a randomized controlled trial on an online labor market in which an additional question was added to the feedback form. Our test reveals that current inflationary norms can be countered. We then develop a theoretical framework to optimize the design of a rating system to maximize the rate of convergence to the true underlying quality distribution.

2 - Optimal Matching with Information Design

Faidra Monachou, Stanford University, Stanford, CA, United States, monachou@stanford.edu, Itai Ashlagi, Afshin Nikzad

We study mechanism design in dynamic markets where objects are allocated to unit-demand agents who have quasi-linear payoffs in their waiting time. We consider a general class of dynamic mechanisms which determine the joint distribution of the object assigned to each agent and the agent's waiting time. We identify the optimal mechanism, and show that when the marketmaker can deploy information design, the outcome of the optimal mechanism can be implemented by a FCFS queue (where agents are allowed to decline offers) and a simple information disclosure policy that pools adjacent object types.

3 - Pricing and Information Design for On-demand Platforms

Guido Martirena, Stanford University, Stanford, CA, United States

I consider the design of information and pricing mechanisms in unobservable queues with strategic and heterogenous customers that are privately informed and time-sensitive. First, I show that if the platform can jointly optimize over pricing and information mechanisms, the optimum can be implemented by disclosing all information and a sequence of posted prices. Second, I identify situations under which information design is profitable and provide a linear program that allows for the computation of the optimal policy. Third, I show that when consumers' private information is multidimensional, the loss from releasing the level of congestion is arbitrarily large relative to the optimal mechanism.

4 - Scrip Systems with Minimal Availability

Süleyman Kerimov, Stanford University, Stanford, CA, United States, Itai Ashlagi

We consider an infinite horizon model with finitely many agents. At each time period, one agent requests service, one agent provides service, and the requester pays one scrip to the provider. Among the agents that are available to provide service, the one with the lowest number of scrips is selected as the provider. Assuming only few agents are able to provide service, we identify conditions, under which the scrip distribution is stable in the sense that free riding is eliminated, and agents do not deviate by much from their initial endowment, with high probability. Our results suggest that scrip systems are likely to lead to efficient outcomes in kidney exchange platforms, where free riding is ubiquitous.

■ WC18

CC- Room 306

Emerging Topics on Additive Manufacturing and Supply Chain

Sponsored: Manufacturing & Service Oper. Mgmt/Supply Chain

Sponsored Session

Chair: Yue Zhang, Pennsylvania State University, University Park, PA, 16827, United States

1 - Assortment Design under Conventional Technologies and 3D Printing

Duo Shi, The Chinese University of Hong Kong, Shenzhen, Shenzhen, 518172, China, shiduo@cuhk.edu.cn, Lingxiu Dong, Fuqiang Zhang

We investigate the impacts of three features of 3D printing, design freedom, quality differentiation, and ultimately flexibility, on a firm's decision of product assortment.

2 - Retailing with 3D Printing

Yao Cui, Cornell University, Ithaca, NY, 14853, United States, yao.cui@cornell.edu, Li Chen, Hau Leung Lee

Given the promise of 3D printing, also known as additive manufacturing, some innovative consumer goods companies have started to experiment with such a technology for on-demand production with mass customization capabilities. However, the potential impact of 3D printing on retail and supply chain operations is not well understood. In this paper, we consider two adoption cases of 3D printing in a dual-channel (i.e., online and in-store) retail setting: 1) when 3D printing is adopted online, 2) when 3D printing is further adopted in-store. Through both adoption cases, we analyze and evaluate the impact of 3D printing on a firm's channel and pricing strategies.

3 - Preventive 3D Printing Spare Parts in a World of IoT

Yue Zhang, Assistant Professor, Pennsylvania State University, 152 Towhee Dr, University Park, PA, 16827, United States, yue.zhang@psu.edu, Jing-Sheng Jeannette Song

We consider using 3D printer to offer preventive after-sales service for spare parts leveraging advanced demand information in a world of IoT.

■ WC19

CC- Room 307

Behavioral Operations & Innovation

Contributed Session

Chair: Crystal Chidinma Chukwuemeka, Doctoral Researcher, University of Manchester

1 - A Subsidy on Effort in Sourcing Model with Credit Guarantee Mechanism

Cheng-feng Wu, Hubei University of Economics, WUHAN, China, d99741006@ntu.edu.tw

This study examines the issue of the strait of capital shortage in SME supplier and supply risks from the buyer's perspective. The buyer builds a credit guarantee mechanism in which a SME supplier is guaranteed to finance the shortfall in capital from the financial institution. Also, the buyer make decisions including placing the order quantity and assessment rate when facing supply risks.

2 - A Behavioral Analysis on the Use of an Intermediary in Manufacturing Outsourcing

Qiong Chen, University of Science and Technology of China, Hefei, China, qcchen@ustc.edu.cn, Aleda Roth, Gulru F. Ozkan-Seely, Fred Switzer

In this paper, we examine how the level of outsourcing competence of the firm, the amount of time-to-market pressure and the buyer's perceived incentive alignment with the agent, act to systematically influence the decision to outsource the new product directly or indirectly through an intermediary.

3 - Pricing Decisions in Revenue Management: An Experimental Investigation

Ummuhan Akbay, Ozyegin University, Istanbul, Turkey, ummuhan.akbay@ozyegin.edu.tr, Nur Cavdaroglu

In this paper we consider pricing and capacity allocation decisions, and report the findings of a decision-making experiment on a two-class airline revenue management problem. We find that on average pricing decisions are not significantly different from the optimal, even when subjects make both decisions simultaneously, suggesting that increased complexity of the decision problem does not necessarily worsen the quality of the pricing decisions. On the other hand, the capacity allocation decisions deviate from the optimal significantly and systematically resulting in a "too low-too high" pattern. We also find evidence of anchoring behavior for both decisions.

4 - Aligning Organizations' Decision Strategy with Employees' Exploration-exploitation Behaviour Using Capital

Crystal Chidinma Chukwuemeka, Doctoral Researcher, University of Manchester, Manchester, United Kingdom, chidinma.chukwuemeka@manchester.ac.uk, K. Nadia Papamichail, Yu-wang Chen, Richard Allmendinger

Retaining talented and valuable employees is a major challenge for firms of all sizes. However, business environments evolve requiring continuous professional development (CPD) here-in referred to as capital. Encouraging CPD, even without talent attrition or employees outgrowing their businesses, remains a challenge. We argue for decision strategy alignment between an organization and its employees. This study investigates capital predictors that enable exploration-exploitation trade-off in CPD trajectories. Preliminary findings show that capital-forms predict 24% variability in vocational decisions. The findings are useful for alignment of talent acquisition and CPD investments.

■ WC20

CC- Room 308

Using OR/Analytics to Study Various Aspects of Student Success

Contributed Session

Chair: Azadeh Ahkamiraad, State University of New York (SUNY) at Binghamton, Binghamton, NY, 13905, United States

1 - The Impact of Being a Procrastinator on Academic Success: A Case Study in an Online Learning Environment

Yasemin Tarakci, Universtiy of North Texas, Denton, TX, United States, Hakan Tarakci

In this paper, we study the performance of students enrolled in a fully online class. We define procrastinators as those who submit their exam within the last 5% of the allotted time. Our findings show that there is a significant difference between the academic performance of the procrastinators and the "punctuals": procrastinators' exam scores are significantly lower than those of the punctuals. We also share these results with the entire class of almost 200 students through an online announcement on the class website. Our follow-up analysis shows that the proportion of procrastinators decreases; in addition, the performance of procrastinator-cum-punctuals improves significantly.

2 - Analyzing Different Levels of Gamification in Engineering Classrooms

Sinan Tas, University of Wisconsin-Platteville, Platteville, WI, United States, sinantas@gmail.com

In this research, using three years of classroom data, we analyze how adding different levels of game elements can affect learning, knowledge, and interest of various student groups based on their major, seniority, and gender. Using knowledge and interest metrics over four areas, including foundation, methodology, tools, and analysis, we conduct statistical analysis in order to study any significant differences among students.

3 - Designing a Sustainable Built Environment for Academic Success

Anita Lee-Post, University of Kentucky, Lexington, KY, United States, dsianita@uky.edu, Chon-huat Goh

Does a sustainable built environment affect students' academic success? We attempt to answer this question by investigating the pathway linking the sustainable design of a campus building to students' academic success. A model mapping the academic support of a campus building's sustainable design features to students' academic success is proposed and validated. The implications of findings from the study will be discussed.

4 - Enhancing Engineering undergraduates' Academic and Professional Experiences Through Social Community

Valerie Washington, University of Michigan, Ann Arbor, MI, United States, vnwashin@umich.edu, Joi-Lynn Mondisa

Research lacks an in-depth examination of the effectiveness of program elements in academic and social support programs designed to increase the retention of undergraduate underrepresented minority students in science, technology, engineering, and mathematics (STEM). In efforts to identify effective program elements, we examine social community elements of the University of Michigan's STEM Academy. We use a Social Community scale and interviews to learn more about past and present participants' experiences. With this understanding, we can better design academic and social support programs.

5 - Bachelor's Degree Programs in Community College: A Solution for Shortage of Operation Research Workforce

Azadeh Ahkamiraad, Graduate Research Assistant, State University of New York (SUNY) at Binghamton, Binghamton, NY, United States, Arefeh Mohammadi

A growing number of community colleges in USA are offering four year bachelor's degree programs to cover the shortage of workforce. Professionals with operation research and management skills are increasingly needed in various service-based companies and businesses. Among these institutions, a lot of healthcare organizations, manufacturing industries, and information technology related companies are exploring new ways to train their employers to obtain skills related to operation research sciences. This study articulates new and affordable pathways to train individuals with expertise in operation research sciences through four years or 2+2 years programs in community colleges.

■ WC22

CC- Room 310

Sustainable Operations in Agriculture

Sponsored: Manufacturing & Service Oper. Mgmt/Sustainable Operations

Sponsored Session

Chair: Buket Avci, Singapore Management University, Singapore, 178899, Singapore

Co-Chair: Bin Li, Singapore Management University, Singapore, Singapore

1 - Economic and Environmental Implications of Biomass Commercialization in Agricultural Processing

Bin Li, Singapore Management University, 50 Stamford Road, Singapore, Singapore, bin.li.2015@pbs.smu.edu.sg, Onur Boyabatli, Buket Avci

Commercializing organic waste (biomass) in various agricultural processing industries has sparked intense debates over its economic and environmental values. Motivated by this, we investigate the economic and environmental implications of biomass commercialization by establishing a stylized model that captures the main operational characteristics in these industries. We find that biomass commercialization serves as a natural hedge against spot price variability and correlation, yet not necessarily leads to lower carbon emissions as commonly perceived.

2 - Seed Manufacturing under Climate Change: The Impact of Higher Yield Variability

Utku Serhatli, INSEAD, Constance de le Boulevard, Fontainebleau, 77590, France, utku.serhatli@insead.edu, Andre Du Pin Calmon, Enver Yucesan

Climate change is the main driver of increasing yield variability in agriculture. We analyze the optimal production decisions of a seed manufacturer facing climate change and the value of operational flexibility in the form of postponement. We use a two-stage stochastic program to derive optimal decisions and use simulations to gain insight on the implication of climate change on food safety. Our analysis shows that a minor increase in yield variability can lead to a major shift in the timing of seed production. Moreover, not only does the value of postponement decreases with increasing yield variability, but low-margin seeds also become more susceptible to yield risk due to climate change.

3 - A Better Buy-one-give-one Business Model

Pi-Ying Yen, The Hong Kong University of Science and Technology, Kowloon, Hong Kong, Ying-Ju Chen, Qiao-Chu He

Buy-one-give-one (BOGO) is a prevailing business model among social enterprises in the agricultural sector nowadays. We find that the social enterprise can create more social welfare by differentiating its products into the high-end products for the purchasers (the rich) and the low-end products for the recipients (the poor) instead of providing these two segments the products of the same quality. Also, giving more products instead of just one to the poor is an effective way to increase social welfare. We also show that BOGO makes higher social welfare than cross-subsidy either when the social enterprise is highly socially responsible or when the social gap between the rich and the poor is significant.

■ WC23

CC- Room 3A

Behavioral Decision Analysis

Sponsored: Decision Analysis

Sponsored Session

Chair: Matthias Seifert, IE Business School, IE Business School, Madrid, 28006, Spain

1 - The Effect of Forecast Inconsistency on User Trust

Jessica N. Burgeno, Graduate Student, University of Washington, Seattle, WA, United States, jburgeno@uw.edu, Susan Joslyn

Forecasts for major weather events often begin days in advance. Forecasters believe consistency among subsequent forecasts preserves user trust and can be reluctant to make changes when potentially more accurate information becomes available. The research reported here compared the effects of forecast inconsistency and inaccuracy. Subjects made decisions based on single-value, sequential snow accumulation forecasts. Both forecast inconsistency and inaccuracy negatively impacted trust; however, the effect of inconsistency was primarily seen when forecasts were accurate. This suggests that maintaining forecast consistency is ill advised when it means a potential loss in accuracy.

2 - Risky Choice Following Near Miss Events in Sequential Tasks under Ambiguity

Florian Federspiel, INCAE Business School, Alajuela, Costa Rica, florian.federspiel@incae.edu, Matthias Seifert, Robin Dillon-Merrill

Studies have shown that near miss events can lead to dangerous inconsistencies in both risk perception and risk taking behavior. Yet near misses are often clouded in ambiguity, allowing for biases and misattribution regarding what caused success or prevented failure. We provide a model of near misses and investigate the experience of such an event on risk taking in a real options task. We show that increases in risk taking following a near miss occur primarily under ambiguity.

3 - Group Decision Making with Multiple Conflicting Performance Targets

Matthias Seifert, Associate Professor of Decision Sciences, IE Business School, CIF B82334319, Maria de Molina 13, Madrid, 28006, Spain, matthias.seifert@ie.edu, Enrico Diecidue, Prana Narayanan

In many multi-stakeholder decision contexts it is of crucial importance to aggregate preferences in a way that rewards the diversity of targets met. Extending Tsetlin & Winkler's (2007) work on multiattribute performance targets, we study the properties of a novel group-weighting rule, which draws on the dis-/similarity of preferences held by individuals and assigns higher values to those alternatives that maximize the diversity of targets achieved. Using a simulation model, we then benchmark the performance of this rule against classic approaches based on equal weighting (e.g. average winner, majority voting).

■ WC24

CC- Room 3B

Risk and Decision Analysis for Infrastructure Resilience

Sponsored: Decision Analysis

Sponsored Session

Chair: Hiba Baroud, Vanderbilt University, Nashville, TN, 37235, United States

1 - Enabling Preemptive Planning and Increased Community Resilience Through Post-disaster Temporary Housing Decision Analysis

Daniel Perrucci, Graduate Researcher, Vanderbilt University, Nashville, TN, 37235, United States, daniel.v.perrucci@vanderbilt.edu, Mohamed Hassan, Hiba Baroud

Over the last three decades, the severity and frequency of natural disasters has experienced an increasing trend which drives the post-disaster displaced populations to unprecedented levels. A multi-objective decision analysis (MODA) will provide government entities the ability to analyze temporary housing alternatives in advance of the disaster displaced population. This prior planning reduces the supply chain uncertainty, and therefore, increases community resilience during the disaster recovery.

2 - Decentralized Decision Making for Interdependent Network and Community Resilience

Buket Cilali, University of Oklahoma, Norman, OK, United States, Kash Barker, Andres David Gonzalez, Nafiseh Ghorbani Renani

Interdependence among infrastructure and community networks is an important aspect to consider when planning for disruptive events. Further, decision makers within different infrastructures often make decentralized decisions to protect and restore their own networks after a disruption. As such, we extend a tri-level optimization model to account for decentralized decisions. Social vulnerability scores are used to show the effect of community resilience and different scenarios are analyzed to reveal the effect of decentralization.

3 - AI for Rapid Damage Assessment

andrea Garcia Tapia, Stevens Institute of Technology, Hoboken, NJ, 07030, United States, agarciat@stevens.edu, Jose E. Ramirez Marquez

Disasters are the consequences of failures in economic development. Rapid damage assessment is critical to for response & recovery. This work has two phases. The first one looks at how to automatize damage detection with drone images. The second asses economic & social impact of the disruption. As case of study we analyzed three communities in Oaxaca, Mexico after the 2017 earthquake. The rapid damage assessment framework is able to detect l&slides & collapsed buildings. If the drone images are georeferenced we could give a map of the damages detected so first aid responders could optimize the help provided. We are currently working on the socioeconomic impact evaluation of the communities.

4 - A Stochastic Approach to Characterize the Persistence of Floods and Droughts Across the Conterminous United States

Jesus D. Gomez-Velez, Vanderbilt University, Nashville, TN, United States

Understanding floods and droughts and their temporal persistence is critical for risk assessment and management under present and future socio-economic and climatic conditions. In this work, a stochastic approach was used to propose novel metrics that characterize the persistence to extreme (high and low) discharge events in watersheds across the US as well as their scaling and connection with climate and infrastructure.

■ WC25

CC- Room 401

Revenue Management, Pricing IV

Contributed Session

Chair: Mojtaba Salarpour, University of Massachusetts-Amherst, Amherst, MA, 01375, United States

1 - Using Markov Chains to understand Pricing Dynamics in the Consumer Electronics Market

Sarah Carron, Ghent University, Ghent, Belgium, sarah.carron@ugent.be, Bram Janssens, Dirk Van den Poel

This research investigates market pricing dynamics in the online and offline consumer electronics industry in Europe among different players. We investigate leader and follower dynamics by performing Markov-chain sequence analysis on pricing data formed through web crawling the important players on the market, covering over 60,000 products.

2 - Price Optimization in Presence of Consumer Rating, Reference Price, and Cross-price Effects

Seyed Shervin Shams-Shoaaee, PhD Student, McMaster University, Hamilton, ON, Canada, shamsshs@mcmaster.ca, Elkafi Hassini

We develop a new demand model accounting for consumer rating, reference price, and cross-price effects in a multi-product, finite horizon, online retail environment. Using this demand model, we introduce a myopic pricing heuristic as well as exact solutions to the optimal pricing problem taking into account the effects of price on future consumer ratings. Furthermore, we present several analytical, managerial, and numerical insights.

3 - A Framework for Pricing Components in a Bundle with Diminishing Reservation Prices

Ritwik Raj, University at Buffalo, Amherst, NY, United States, r28@buffalo.edu, Mark Henry Karwan, Chase Murray, Lei Sun

We study pricing bundle components for a case in which consumers decide the bundle composition; and the valuation of components diminishes with the valuation of the bundle. We calculate the optimal bundle price to maximize expected profit. We also calculate the optimal split of the bundle price into component prices to maximize customer satisfaction. A complete analysis for the two-product bundle case in which stand-alone reservation prices are independent and uniformly distributed, is provided. Numerical results show that both expected profit and customer satisfaction are high when there is heterogeneity among bundled products.

4 - On the Equilibrium of Elections Game under: Majority Rule and Electoral College

Charles Thraves, Assistant Professor, University of Chile, Santiago, Chile, cthraves@dii.uchile.cl

We model elections where candidates maximize probability of winning under a game theory model. We study the equilibrium under a deterministic and stochastic model, proving its existence and uniqueness in pure strategies in a deterministic setting in a majority rule system. We then introduce a stochastic version of the game and draw insights on the equilibrium obtained through numerical instances. In addition, we describe the corresponding algorithm in each case to find the game equilibrium.

5 - An Integrated Financial and Logistical Game Theory Model for Humanitarian Organizations

Mojtaba Salarpour, University of Massachusetts-Amherst, Amherst, MA, United States, msalarpour@umass.edu, Anna B. Nagurney, Patrizia Daniele

In this paper, a game theory model for disaster relief is constructed that incorporates both financial and logistical aspects of humanitarian organizations involved in the purchasing and delivery of relief items, post-disaster, using freight services. The governing concept is that of Generalized Nash Equilibrium, since not only does the utility function of a given humanitarian organization depend on its own strategies and the strategies of the other humanitarian organizations, but the constraints do as well. The concept of a variational equilibrium is utilized to derive the variational inequality formulation of the equilibrium conditions and a case study inspired by Hurricane Harvey presented.

■ WC26

CC- Room 4C-1

Ride-sharing Service

Contributed Session

Chair: Maxime Cohen, NYU Stern, New York, NY, 10012, United States

1 - Can Car Sharing Disrupt Car Ownership? A Conjoint Study of Consumer Mobility Choice

Lixian Qian, Xi'an Jiaotong-Liverpool University, Suzhou, China, lixian.qian@xjtlu.edu.cn, Zhan Pang, Didier Soopramanien

This paper investigates the broader effect of introducing car sharing, also called on-demand car rental, on urban mobility system. By conducting a choice-based conjoint study in Beijing, we identify a nested structure where bus and underground fall in a nest of "public transit" while car sharing, private car and taxi are independent in respective degenerate branches, which implies that unexpectedly car sharing is a proportional substitute to other mobility modes. Public transit users who intend to buy their first cars are more likely to adopt car sharing than car owners, which implies that introducing car sharing may indeed retard the growth of car ownership but attract public transit users to drive.

2 - Consumer Heterogeneity in Preferences for Risk-mitigating Service Attributes in the Sharing Economy: Evidence from Ride-sharing Services

Soo Jeong (Chris) Hong, Pepperdine University, Malibu, CA, United States, soojeong.hong@pepperdine.edu, Johannes M. Bauer, Kwangjin Lee, Nelson Granados

Taking advantage of ubiquitous Internet connectivity and new information technologies, platform businesses in the "sharing economy" have been rapidly growing. However, their new forms of service provision raise several issues that may concern consumers and influence their decision to adopt such services. Empirical data suggests consumer response has been mixed, with certain groups embracing the new services but others reluctant to use them. Focusing on ride-sharing services, we examine the effect of service features that would not only mitigate perceived individual risks but also reduce broader societal concerns on consumers' willingness to pay for the service.

3 - Effects of Flexibility and Security on the Decision to Work for Ride-sharing Services

Kwangjin Lee, Pepperdine University, Malibu, CA, United States, Soo Jeong (Chris) Hong, Johannes M. Bauer, Nelson Granados

This study investigates the effects of granting service providers of ride-sharing services, a menu of contracts with varying flexibility on their willingness to offer their services through a platform. Ride-sharing is one of the largest sectors in the sharing economy and can provide insights that can apply to other services in this emerging sector. Using a choice experiment, the study examines how diversification of contractual attributes affects drivers' willingness to work for the online platform. It also investigates whether service providers' preferences for flexibility and stability in the platform business are influenced by alternative employment options.

■ WC27

CC- Room 4C-2

Innovative Operations in Digital Economy

Sponsored: Service Science

Sponsored Session

Chair: Jiayi Joey Yu, University of California-Berkeley, Berkeley, CA, 94720, United States

1 - A Data Analytics Approach to Integrated Location Assortment and Inventory Planning in Omni-channel Retail

Hao Shen, Renmin University of China, Beijing, China, Jian Chen, Yong Liang, Zuo-Jun Max Shen

While the rise of e-commerce provided retailers with new avenues to reach customers, fierce competition has pushed retailers to turn to data and analytics to make better business decisions. Observing retailers aggressively expanding in both online and offline channels, we study a data analytics approach enabling omni-channel retailers to make better location, assortment, and inventory decisions to maximize profits. We develop an efficient reformulation to solve the proposed decision model, and draw interesting observations that can be valuable to practitioners.

2 - Pricing and Rationing with Inventory Build-up in New Product Di Usion

Mengying Xue, Purdue University, West Lafayette, IN, United States, mengying.xue@gmail.com, Long He, Max Shen, Max Shen

It is critical for a firm to manage the demand when launching a new product. The customers' word-of-mouth e ect plays an important role in the demand di usion of a new product in the market. In this paper, we study the dynamic pricing strategy of a firm facing strategically waiting customers under the supply constraints. The firm has to make decisions on prices and initial inventory at the same time. A stylized twostage discrete-time model where the firm has no commitment power is considered, and demand is modeled as a modified Bass di usion process by introducing information flow. We characterize the existence and optimal conditions for each pricing and rationing strategy—constant high price, constant low price, price penetration, and price skimming. When the initial inventory build-up is free, our analysis highlights the tradeo between taking advantage of the demand di usion and combating with customers' strategic waiting. For example, when customer valuations are more polarized, it is optimal for the firm to only satisfy the high-value customers but still ration them in the first stage due to customers' strategic waiting behavior, if the word-of-mouth e ect in demand di usion is weak. In contrast, with stronger word-of-mouth e ect or less polarized customer valuations, it is better for the firm to penetrate the market with a low initial price. When it is costly to acquire initial inventory, the firm also needs to factor in the inventory build-up cost in the tradeo . We provide the optimal initial inventory level in joint with the pricing and rationing strategy for ranges of inventory cost and word-of-mouth e ect.

3 - Robust Transportation Scheduling and Parcel Pricing for Same-day Delivery

Mengxin Wang, University of California-Berkeley, Berkeley, CA, 94703, United States, mengxin_wang@berkeley.edu, Junyu Cao, Zuo-Jun Max Shen

We study an efficient transshipment-based same-day delivery system which combines the RDC-based system and the point-to-point system. In the transshipment-based system, the entire service region is divided into several subregions with transfer depots. A main-line network connects all the depots. We propose a data-driven framework to jointly design a robust main-line schedule and parcel price for daily delivery operations. We demonstrate the performance of our method using real data from a same-day delivery company in Beijing, China.

■ WC28

CC- Room 4C-3

Game Theory I

Contributed Session

Chair: Senthil Kumar Anantharaman, IIm Indore, Rau-Pithampur Road, In, indore, 453556, India

1 - Profit-Sharing and Efficient Time Allocation

Miguel Vargas, Research Professor, Santiago de Cali University, Cali, Colombia, miguel.vargas02@usc.edu.co

Agents are endowed with time, which in turn is invested in projects that generate profit. A mechanism divides the profit generated between these agents, depending on the allocation of time as well as the profit made by every project. We study mechanisms that incentivize agents to contribute their time to a level that results in the maximal aggregate profit at the Nash equilibrium (efficiency). Our main finding involves the characterization of all mechanisms that satisfy efficiency. We characterize the class of mechanisms that are monotone in the payoffs of the agents with respect to technological improvements, the addition of time to agents, and mechanisms that are resistant to group manipulations.

2 - Games of Agreement

Chunlin Wang, Assistant Professor, Davis College of Business and Economics, Radford University, Radford, VA, United States, cwang17@radford.edu, Joyendu Bhadury

We introduce the notion of a "game of agreement" that is an extension of the well-known "Battle of the Sexes" game with the following characteristics. The game attempts to model situations where multiple parties (buyers-sellers, labor unions-management etc.) need to come to an agreement on a common issue in order for all players to be better off. We characterize the mixed-strategy Nash Equilibrium of such games by demonstrating the existence of one and then proving that under the assumption of all players using "good-faith" mixed strategies, the Nash Equilibrium we propose is unique.

3 - Benefits of Cooperation Through Shared Demand Information and Inventory Centralization in Newsvendor Settings

Juan Carlos Gocalves Dosantos, Universidade da Coruña, La Coruña, Spain, juan.carlos.goncalves@udc.es, Fernando Bernstein, Ana Meca

We consider a set of retailers serving independent regions. Each retailer manages its own inventory based on the newsvendor model. Retailers may cooperate in the acquisition of future demand information. Our goal is to quantify the benefits that can be achieved by sharing future demand information cooperatively. We then explore a setting in which retailers can cooperate not only through the acquisition of future demand information, but also by centralizing their inventories. We study the core of these cooperative games and propose appealing allocation schemes of the benefits of cooperation.

4 - Patrolling Security Games Against Mobile Intelligent Adversaries

Zhifan Xu, Rutgers, The State University of New Jersey, New Brunswick, NJ, United States

Patrolling is an important operational decision when safeguarding a public area against adversarial attacks. In this paper, we propose a discrete time Stackelberg security game on a graph in which the defender announces her patrolling policy at first. The attacker then decides on his target and his route by solving a Markov decision process, given the defender's patrolling policy and the observation of the defender's location at every turn. We also introduced the concept of detection probability for each node on the graph. To find the Stackelberg equilibrium strategies for both players, we derived a bi-level program that can be solved via bilinear programming or global optimization techniques.

5 - Modelling Public Private Partnerships Applying Game Theory

Senthil Kumar Anantharaman, Doctoral Student, IIm Indore, indore, India, f16senthilk@iimidr.ac.in, Rohit Kapoor

Governments have been preferring public-private-partnership(PPP) over traditional methods in the past few decades to procure public services for their citizens. This study provides a base for implementing PPP contractual mechanism, when the government needs to maximize it social surplus or value for money (VFM). Further, the study attempts to model the relationships between three players in a principal agent model where government and equity/lender act as the principals and the service provider act as the agent. Finally we portray the optimal contract set at equilibrium conditions that consider moral hazard, signalling aspects, incentivization and matching across the contract cycle.

■ WC29

CC- Room 4C-4

Multidimensional Mechanism Design

Sponsored: Auction and Market Design

Sponsored Session

Chair: Justin Burkett, Georgia Institute of Technology, Atlanta, GA, 30313, United States

1 - A Revealed Preference Approach to Multidimensional Screening

Maxwell Rosenthal, Georgia Institute of Technology, Atlanta, GA, United States

This paper develops a data-driven approach to screening. The principal observes a population of decision makers each choose from a finite number of exogenous sets of alternatives, and her beliefs about the agent's preferences are informed by these choices. However, there are many type distributions that are consistent with the choice data. Rather than assign privilege to any one distribution, she evaluates mechanisms according to their worst-case payoff against the set of consistent distributions. We study the relationship between optimal mechanisms and the choice environments in the data set, which do not in general coincide.

2 - Welfare Properties of Competitive Insurance Markets with Risk and Preference Heterogeneity

Vitor Farinha Luz, University of British Columbia, Vancouver, BC, Canada, Humberto Moreira, Piero Gottarde

We consider a model of insurance provision with two-dimensional private information. Consumers are privately informed about their risk level and level of risk aversion. Equilibria necessarily involve pooling, mixing agents with similar willingness to pay for coverage.To study the impact of heterogeneity in risk aversion on the benckmark one- dimensional competitive insurance model we propose a novel approach. We perform a perturbation to this benchmark model allowing for a "small" amount of heterogeneity in the risk aversion dimension. This approach allows us to obtain explicit formulas for the dependence of equilibrium outcomes on the type distribution.

3 - Dynamic Mechanisms with Private Discount Factors

Justin Burkett, Georgia Institute of Technology, Atlanta, GA, United States, justin.burkett@gatech.edu, Kyle Woodward

We consider the optimality of static mechanisms in dynamic contexts. In our model participants have private values and discount rates, and the mechanism designer can use the passage of time as a screening device for surplus extraction. When discount rates and values are positively related, it is optimal for the designer to allocate the good immediately and ignore the screening potential of time. When discount rates and values are negatively related, the seller can use time as a screening device, and extract high-value participants' rents today and low-value participants' rents tomorrow. Our results generalize to non-standard discounting and arbitrary time horizons.

4 - Large Matchings in Large Markets with Flexible Supply

Shunya Noda, University of British Columbia, Vancouver, BC, Canada, shunya.noda@gmail.com

This paper studies the matching size achieved by strategy-proof mechanisms in a general model of matching with constraints. We show that naïve extensions of classical mechanisms may generate an arbitrarily small matching. Assuming a large market, we develop a technique to reshape a given resource constraint to a more structured one with which a classical mechanism performs well. We propose a mechanism that (i) satisfies strategy-proofness, (ii) always achieves at least 1-1/e = 63.2% of the maximum size (which is the best approximation ratio a strategy-proof mechanism can achieve), (iii) respects agents' preferences, and (iv) is computationally efficient, for general instances.

■ WC30

CC- Room 6A

Retail Management

Contributed Session

Chair: Somak Paul, The Ohio State University, Columbus, OH, 43201, United States

1 - Modeling Purchase Decision Making at a Large Electronics Retailer

Bram Janssens, Ghent University, Ghent, Belgium, bram.janssens@ugent.be, Sarah Carron, Dirk Van den Poel

This study tries to model the purchasing behavior of customers at a large European electronics retail company. Building a two-stage model with both classification and regression trees, we try to pinpoint which are the most important determinants in the purchasing decision. Initial results show that, contrary to what was initially assumed, customers simply compare the retailer's price to the lowest market price, making the purchasing decision simpler than hypothesized. This would also imply that customers do not distinguish between online players and brick-and-mortar players.

2 - Fulfillment by Amazon Versus Fulfillment by Seller: An Interpretable Risk-adjusted Fulfillment Model

Libo Sun, University of Science & Technology of China, Hefei, China, libosun@mail.ustc.edu.cn, Guodong Lyu, Yugang Yu, Chung-Piaw Teo

With dual-channel choices, E-retailers fulfill their demands by either the inventory stored in third-party distribution centers, or by in-house inventory. Using data from a wedding gown E-retailer in China, we analyze the differences between two fulfillment choices - Fulfillment by Amazon (FBA) and Fulfillment by Seller (FBS). We develop a risk-adjusted fulfillment model to address this problem, where the e-retailer's risk attitude to FBA is incorporated. We apply our model on a set of real data, and develop an explicit decision rule that can be easily implemented in practice. The numerical experiments show that our interpretable decision rule can improve the E-retailer's rewards by about 48%.

3 - Optimizing Consumer Subscriptions in Online Rentals

Emre Eryigit, PhD Student, UMASS-Amherst, Amherst, MA, United States, Ahmed Ghoniem, Bacel Maddah

We consider an online retailer renting out products (e.g., fashion goods) to heterogeneous customers subscribed at different levels. Assuming that Subscribed customers only incur a periodic subscription fee, we address the retailer's problem of maximizing the expected profit by determining the optimal product assortment, the structure of the subscription levels, and the subscription fee. Realistic demand and cost functions are adopted.

4 - Buy Online Fulfill from Store - Design and Control of Order Picking Operations

Wen Zhu, New Jersey Institute of Technology, Newark, NJ, United States, wz83@njit.edu, Sanchoy Das

Fulfilling online orders from store inventory (S-Strategy) is a growing retail strategy. The primary goal of an S-Strategy is immediate order fulfillment, allowing the retailer to provide a faster service rate than fulfillment center (F-Strategy) solution. In the nominal case, orders are picked from shelf inventory, for the advanced case, popular items are assigned to fast picking zones. This research uses a database driven simulation model to evaluate the fulfillment capabilities of the S-Strategy. Models to assign items to fast picking and schedule pickers to minimize order delays and costs are presented.

5 - Estimating Consumer Decision Trees Using Aggregate Sales Data Without Identified Customers

Olga Pak, Penn State, State College, PA, United States, Olga Perdikaki, Mark Ferguson, Su-Ming Wu

In marketing and operations management research, limited attention exists on developing algorithms that allow to generate, analyze, and test theoretically driven but data-informed decision trees. Our study utilizes demand structures extracted from retail scanner data and tests dynamic hierarchies of consideration choices as decision trees. This approach has several advantages. We use widely available scanner purchase data across multiple markets and multiple stores, which involves a larger pool of customers and products. Also, our methodology allows to break away from the current assumptions of fixed product choice and consideration sets within and between stores.

6 - To Split or Not to Split - Order Characteristics That Generate Customer Calls for Split Request in Retail

Somak Paul, The Ohio State University, Columbus, OH, United States, paul.865@osu.edu

The retail fulfillment literature has looked into the order delivery from a cost minimization perspective. However, there are cases where the customer calls up the customer service to request split delivery, while the retailer is trying to bundle up the items to provide single delivery. We investigate order characteristics for a Fortune-500 furniture retailer that faces such issue. Current policy is to deliver all items at the same time - which for orders with multiple items results in a lead-time of over 1.5 months. We develop algorithms to determine whether/how to split orders into multiple shipments to enhance customer satisfaction.

■ WC31

CC- Room 6B

Applied Statistical Studies

Sponsored: Military and Security

Sponsored Session

Chair: Mark A Gallagher, Air Force Institute of Technology, Columbus, OH, 43229-5535, United States

1 - Bayes Networks Versus Discrete Event Simulations

Mark A. Gallagher, Air Force Institute of Technology, Columbus, OH, 43229-5535, United States, markgallagherJMJ@gmail.com, Aaron Salazar

We explore comparing the outputs from discrete-event simulation models and Bayesian Networks. We start with known models, such as a queuing modeling, as a baseline to solve and extract true values. We formulate a simulation to estimate the underlying distribution and behavior of the modeled system. We also construct a Bayesian Network for comparison. We evaluate the output distribution (based on replications with the simulation and the Bayesian Network). We also examine computational time of the two approaches.

2 - A Multivariate Statistics Perspective of Military Conflicts and War

Mark A. Gallagher, Air Force Institute of Technology, Columbus, OH, 43229-5535, United States, markgallagherJMJ@gmail.com, Brandon Hufstetler, Marc Chale

We constructed an extensive database on statistics and indices on countries from the year 2000 through 2018. We applied various multivariate statistics techniques to gain insights to what conditions exist on countries being involved in war and less armed conflicts.

3 - Artillery Firing Shift with Multiple Registration Targets

Michael Bendersky, Holon Institute of Technology, Holon, Israel, michael.bendersky@gmail.com

Firing Shift is the shifting of artillery fire from one target to another with the application of corrections determined from the adjustment on the first target to the initial firing data on the second. We investigate the shift accuracy when using a simultaneous fire adjustment for two different registration targets rather than a single one. We use the resulting data to solve explicitly for four major environmental factors which affect ballistic trajectories and update them consequently for the application mission. We determine the distribution of the remaining error at the application and compare the resultant accuracy with that of the existing method.

■ WC32

CC- Room 6C

Strategy/Strategic Planning

Contributed Session

Chair: Xufeng Yao, Arizona State University, Tempe, AZ, 85281, United States

1 - CSR Breadth or Depth? The Effect of External NGOs and Partner NGOs Pressure on the CSR Choice of a Firm

Shaili Singh, Research Scholar, Indian Institute of Management, Rohtak, India, singhshaili631@gmail.com, Mahua Guha

This study analyzes the influence of secondary stakeholders in the form of NGOs on the CSR choice of a firm. Drawing from the stakeholder theory we model two NGO-firm interactions as: 1. External NGOs which exists in the organizational field as the pressure group 2. Partner NGOs which aid firms in implementing their CSR. We empirically investigate if differences in the firms' CSR choice in the form of CSR breadth, depth and spending are related to the varying impact of the two types of NGO-firm interactions. We use a sample of Indian firms listed on the National Stock Exchange. Indian context is unique for this study as it is the first country with mandatory CSR for all firms falling under a certain criterion.

2 - Firms' Relational Capabilities and Performance: Mediating Role of Dynamic Capability

Ritu Singh, Indian Institute of Management Raipur, Raipur, India, ritu.fpm2015@iimraipur.ac.in

Drawing on the firm's relational view and literature on dynamic capability, this study investigates the interdependencies among the firm's relational capabilities, dynamic capability, and performance using structural equation modeling technique. The findings show that dynamic capability strongly mediates the effect of relational capabilities on performance. This study contributes to the management literature by integrating outward-looking perspective (i.e. firm's relationships) and inward-looking perspective (i.e. dynamic capability) and investigating these relationships in the context of emerging economies.

3 - How Do Advisors Influence on M&A? – An Analysis of Acquisitions in Japan

JaSeung Koo, PhD, Kyoto Sangyo University, Kyoto, Japan, koo.academic@gmail.com

M&A advisor is one of the most popular topics in acquisition studies. This study focuses on the differentiated influence of sell-side advisors and buy-side advisors on the deal progress. Unlike prior studies on M&A advisors, the study addresses different roles of target and acquirer advisors and explores their influences on the cumulative abnormal returns (CAR) and acquisition premiums with an empirical analysis of longitudinal data for listed Japanese non-financial firms' M&As between 1991 and 2012. The empirical result supports hypotheses of target advisor's positive association with CAR and acquirer advisor's positive association with acquisition premiums.

4 - Strategic Supply Chain Planning under Tariff Fluctuation and Demand Uncertainty

Xufeng Yao, Arizona State University, Tempe, AZ, United States, xufeng.yao@asu.edu, Ronald Askin

Long term strategic planning for a company with global supply chain network should take uncertainties such as tariff fluctuation, demand volatility in the decision-making process since those uncertainties are major factors that directly impact the profitability/survivability of such a global company. A stochastic programming model using flexibility options as a way to neutralize the effects of the uncertainties involved is proposed to deal with long term global supply chain planning problem.

■ WC33

CC- Room 602

Intelligent Agents and Systems

Contributed Session

Chair: Carlos Paternina-Arboleda, Universidad del Norte, Km 5 Via Puerto Columbia, Atlantico, Barranquilla, Colombia

1 - Modeling the Competitive Dynamics of the Multi-sided Mobile-wallet Market Using Agent-based Modeling

Muhammad Adeel Zaffar, Lahore University of Management Sciences, Lahore, Pakistan, adeel.zaffar@lums.edu.pk, Ram Kumar, Kexin Zhao

There is a dearth of research on understanding the competitive dynamics of multi-sided platform markets. In the backdrop of the growing fintech market, we propose an agent-based model to investigate factors that affect diffusion dynamics of mobile wallets in a dynamic multi-sided environment. In particular, the model focuses on the conditions under which an incumbent player exists in the market and is competitively threatened by the arrival of a newcomer. The model and its insights can be generalized in the context of any emerging platform in which more than two sides affect the value proposition and competitive dynamics of the platform operators.

2 - Leveraging Probabilistic Features of Artificial Intelligence to Induce and Sustain Perceived Humanness and Trust

Kambiz Saffarizadeh, Georgia State University, Atlanta, GA, United States, ksaffarizadeh1@gsu.edu, Mark Keil

As AI artifacts become more complicated, users face more indeterminacies in their interactions with them. We define AI indeterminacy as the unpredictability in the AI's behavior that seems not to have a directly observable cause. We posit that AI indeterminacy has paradoxical effects on the user's trust in the AI because it simultaneously decreases the perceived reliability of the artifact and increases its perceived humanness. Drawing on the uncanny valley and anthropomorphism streams of research, we explain why such paradox exists and how it changes over time.

3 - Landmark-aided Localization and Routing of Unmanned Vehicles: An Integer Programming Model, Polyhedral Analysis and Exact Algorithm

Bingyu Wang, PhD Candidate, Texas A&M University, College Station, TX, United States, bywang_xjtu@tamu.edu, Sivakumar Rathinam, Kaarthik Sundar

Unmanned Vehicles (UVs) have widespread civil and military applications. Localization is crucial for reliable navigation of UVs. In GPS-denied environments, detection of known LandMarks (LMs) from on-board sensors is an effective way of localization. We propose a joint optimization problem to simultaneously plan good paths for a fleet of UVs and place additional LMs strategically in the environment to aid localization. This problem is a variant of the multi-depot TSP with set-covering constraints. It is formulated as an integer-linear program for which polyhedral analysis and an exact algorithm are proposed. Simulation results corroborate our proposed method.

4 - Fleet Mix Optimization under Uncertainty: Evaluating Electromobility in Urban Logistics

Allan Larsen, Technical University of Denmark, Lyngby, Denmark, alar@dtu.dk, Satya Sarvani Malladi, Jonas Christensen, David Ramirez, Dario Pacino

We study the problem of optimizing the size and mix of the commercial mixed-electric fleet owned by a firm providing urban logistics services. In this problem, we consider uncertain customer requests at the strategic planning stage that are revealed before operations commence on each day. We upgrade the energy consumption model to capture the effect on temperature through the auxiliary energy component of heating and cooling loads of climate control. To solve the problem, we propose a simulation based approach at the strategic level, employing a novel adaptive large neighborhood search method for determining the operational decisions for each day.

5 - ZEV Routing and Fleet Size Minimization for Drayage Operations

Shichun Hu, University of Southern California, Los Angeles, CA, United States, shichunh@usc.edu, Maged M. Dessouky

Zero Emission Vehicles (ZEVs) have been introduced to the freight industry as a green solution for freight operations. However, the fact that ZEVs have less mile range per fueling and much longer fueling times could offset their benefits thus making it harder to replace diesel trucks. We focus on the drayage operation and propose to solve the routing and fleet size minimization problem to maximize the advantages of ZEVs.

6 - Geo-prescriptive Inventory Routing Problem

Carlos Paternina-Arboleda, Universidad del Norte, Km 5 Via Puerto Columbia, Atlantico, Barranquilla, Colombia, Daniela Cassandro-De la Hoz

Inventory Routing problems, a sub-set of vendor managed inventory problems, have commonly been solved with on-hand information available. We propose a method to perform prescriptive analytics to geographically learned demand patterns in hardware store retail companies before they are formally released to a supplier so as to propose a-priori routes for planned inventory.

■ WC34

CC- Room 603

Optimization, Robust I

Contributed Session

Chair: Ning Zhu, Tianjin University, Tianjin, China, Tianjin, China

1 - Multistage Adaptive Robust Unit Commitment Model with the Ellipsoidal Uncertainty Set for Demand Uncertainty

Jaehee Jeong, KAIST, Daejeon, Korea, Republic of, jh5290@kaist.ac.kr, Sungsoo Park, Hwayong Choi

Since the current power system operation has become complicated due to the volatilities in the current supply and demand, an accurate robust unit commitment (RUC) model has become more important. The drawbacks of the previous models is that they are two-stage models which do not consider the nonanticipativity of the dispatch decisions, and they use the cardinality constrained uncertainty set. We propose the multistage RUC model with an ellipsoidal uncertainty set and reformulate it as tractable one. We develop a pseudo-exact separation procedure for the constraint generation framework for the problem. Numerical results on an IEEE 118-bus system are reported.

2 - Probabilistic Guarantees in Robust Optimization: A General Methodology

Jean Pauphilet, Massachusetts Institute of Technology, Cambridge, MA, United States, jpauph@mit.edu, Dimitris Bertsimas, Dick den Hertog

We develop a principled methodology to derive probabilistic guarantees for solutions of robust optimization problems, for general uncertainty sets and general constraints. Our analysis recovers and extends most results available in the literature. We introduce the notion of robust complexity of a set, which is a robust analog of the Rademacher complexity encountered in statistics, and which drives our a priori bounds. We also derive improved a posteriori bounds, i.e., bounds which depend on the resulting robust solution. These bounds are notably tighter and computable for any general convex uncertainty set. We illustrate our findings on numerical experiments.

3 - Production Planning under Uncertainty via Distributionally Robust Optimization

Shunichi Ohmori, Waseda University, Tokyo, Japan, ohmori0406@gmail.com, Kazuho Yoshimoto

With the changing market conditions, the impact of uncertainties in supply chains became even more vital. The traditional approach is stochastic-programming, which is powerful if the probability distribution is known. In practice, however, the distribution is never observable but must be inferred from data. In this research, we study the effectiveness of an alternative approach, distributionally robust optimization, in which the objective is to minimize the worst-case expected cost over an ambiguity set, that is, a family of unknown distributions with certain known properties. Thereby, we do not need to assume distribution, yet make a decision from data with better out-of-sample performance.

4 - Robustness Analysis of UAV Information Collection Path under Limited Bandwidth

Ningji Wei, University at Buffalo, SUNY, Buffalo, NY, United States, ningjiwe@buffalo.edu, Jose Luis Walteros

In this project, the we developed models to analyze the robustness of the information collection and distribution plans in cases where the adversarial team (the red team) actively attempts to limit the amount of information that can be collected by the blue team. The principal objective of this study is then to analyze the negative effects that a conscious adversary can inflict on the information collection and distribution plan.

5 - A Distributionally Robust Approach to Virtual Station Location Problem for Free-float Bike-sharing System

Ning Zhu, Tianjin University, Tianjin, China, zhuning@tju.edu.cn, Chenyi Fu

Bike-sharing systems have been developed around the world over the past several decades. Recently, some investors in bike-sharing industry, such mobike and ofo in China, begun to employ the free-floating mode, which allows the customers use the official Apps in phones to search, rent and return the bikes without the restriction of going to fixed stations. In this study, a strategic planning is investigated to determine the vitural station location and size of bike allocation in each zone under a given initial budget. A distributionally robust approach is employed to model this problem. The numerical results show advantages of the robust approach.

■ WC35

CC- Room 604

Applications in Mixed-Integer Quadratic Programming

Sponsored: Optimization/Integer and Discrete Optimization

Sponsored Session

Chair: Boshi Yang, Clemson Unviersity, Clemson, SC, United States

1 - New Relaxations for Composition of Univariate Functions

Taotao He, Purdue University, West Lafayette, IN, 47906, United States, he135@purdue.edu, Mohit Tawarmalani

Recently, a new relaxation, referred to as composite relaxation, has been introduced for composite functions. In this talk, we discuss two extensions of the composite relaxation. First, for composite functions with discrete univariate inner-functions, we obtain ideal logarithmic MIP formulations for their graphs. Second, for composite functions with continuous univariate inner-functions, we construct a sequence of polyhedral relaxations that converge, in the limit, to the concave envelope.

2 - Globally Solving ACOPF by Exploiting Semidefinite-ness and Compact Disjunction

Yunqi Luo, Washington State University, Pullman, WA, United States, Hongbo Dong

ACOPF is one of the most fundamental optimization problems in power system operation. Various approaches based on semidefinite relaxations and analysis of low-dimensional convex hulls have been proposed in the article, with different strengths and drawbacks. Our contribution is to refine some existing approaches exploiting semidefiniteness and combine with recently proposed compact disjunctive approximation schemes, yielding an approach that can exploit state-of-the-art global solvers for mixed-integer convex programs and approximate the ACOPF problem in arbitrary precision. We report numerical results on various instances used in the literature.

3 - Integer Programming for Envy-free Equilibrium Pricing

Hamid Nazari, Clemson University, Central, SC, 29630, United States, snazari@clemson.edu, Akshay Gupte

We are interested in solving a combinatorial matrix assignment problem which appears in literature as a bundle pricing problem in a multi-buyer-single-seller market. It can be formulated as a MINLP when general utility functions are used, and reduces to a MIQP when the standard assumption of linear utilities is made. This problem has been extensively studied in literature from the computational complexity perspective. We work within the framework of general utilities and derive many properties of optimal solutions. Using disjunctions we also found valid inequalities to cut the exponential feasible set. Some computational results are provided to test the effectiveness of our properties.

4 - Using Conditional Logic to Tighten Miller-tucker-zemlin Inequalities for the Target Visitation Problem

Boshi Yang, Clemson University, Clemson, SC, United States, boshiy@clemson.edu, Audrey Nicole DeVries, Warren P. Adams

This talk exploits the variable structure of the target visitation problem (TVP) to derive a tightened version of the Miller-Tucker-Zemlin (MTZ) inequalities. The TVP is a hybrid between the traveling salesman problem (TSP) and the linear ordering problem (LOP), and uses both variable sets. Our strengthened MTZ inequalities are computed via a two-step approach; the first step uses a conditional logic argument involving both variable sets to motivate valid quadratic inequalities, and the second step suitably surrogates these inequalities to eliminate the quadratic terms. This approach, while devised for the TVP, affords a general framework for cuts for the TSP, the LOP, and the quadratic TSP.

■ WC37

CC- Room 606

Power System Operation During Extreme Weather

Sponsored: Optimization/Optimization Under Uncertainty

Sponsored Session

Chair: Mostafa Sahraei-Ardakani, University of Utah, Salt Lake City, UT, 84112, United States

1 - Power Outage Forecasting for Adverse Weather Events

Chengwei Zhai, University of Michigan, Ann Arbor, MI, United States, Seth Guikema, Steven Quiring, Roshanak Nateghi, Elnaz Kabir, Sara Shashaani

Hurricanes and other extreme weather events regularly cause substantial damage to power systems. Pre-event forecasts of the degree and spatial distribution of power outages can be of substantial benefit in planning recovery efforts. This talk gives an overview of developments in power outage forecasting for weather events, focusing on probabilistic forecasts.

2 - Sequentially Proactive Operation Strategies for Power Systems under Extreme Weather Events

Yunhe Hou, The University of Hong Kong, Hong Kong, Hong Kong, yhhou@eee.hku.hk

This talk will discuss a sequential operating strategy for mitigating the impacts of a large-scale power system due to extreme weather events (EWEs). The sequential characteristics of EWEs and their potential damages on power systems are modeled with a Markov process. Transition probabilities are evaluated according to failure rates caused by extreme events. For each state, a recursive value function, including a current cost and a future cost, is established with operation constraints and intertemporal constraints. An optimal strategy is established by optimizing the recursive model. The proposed method has been tested on standard and realistic systems.

3 - Scalable Stochastic Unit Commitment During Hurricanes

Farshad Mohammadi, University of Utah, Salt Lake City, UT, United States, farshad.mohammadi@utah.edu, Mostafa Sahraei-Ardakani

Stochastic unit commitment with a large uncertainty set is a computationally challenging problem. The computational burden becomes challenging when the uncertainty affects integer variables, such as line status. In this talk, a new formulation is presented, which is able to solve the preventive unit commitment problem for large-scale networks. To model the damage caused by hurricanes, the uncertainty in the formulation will be the status of transmission lines that are in the hurricane track. The results show that our method can effectively solve the problem within an acceptable time and significantly reduce the power outages, through finding a preventive commitment.

4 - Planning the Grid Against the Extremes

Rodrigo Moreno, University of Chile, Tupper 2007, Santiago, Chile, rmorenovieyra@ing.uchile.cl

Although extreme natural disasters have occurred all over the world throughout history, power systems planners do not usually recognize them within network investment methodologies. To move towards a resilience centred approach, we propose a practical framework that can be used to identify network investments that offer the highest level of hedge against risks caused by natural hazards. In a first level, our framework proposes network enhancements and, in a second level, uses a simulation to evaluate the resilience level improvements associated with the network investment propositions. We use this modeling framework to find optimal portfolio solutions for resilient network enhancements.

■ WC38

CC- Room 607

Optimization, Stochastic III

Contributed Session

Chair: Parsa Kianpour, Wichita State University, Wichita, KS, 67206, United States

1 - Investment Optimization of Railway Wagon Maintenance Equipment Based on Stochastic Programming

Qi Li, Associate Professor, Beijing Jiaotong University, Beijing, China, liqi@bjtu.edu.cn, Le Liu, Zengqiang Jiang, Mingcheng E, Jing Ma

Appropriate equipment investment is vital to business management. In this research, a two-stage stochastic programming model considering uncertainties is proposed to maximize investment profile of maintenance facilities for the wagon. The uncertainties are mainly including various maintenance demand based on remaining useful life prediction of wagon components, equipment price and available investment funds in every period. A case study based on a railway wagon maintenance company in China was carried out to verify the proposed model. The preliminary results show that the stochastic programming model is a promising method for enterprise equipment planning under uncertainties.

2 - Two-stage Stochastic Assignment Problem with Applications to Postage Sorting

Natasja Sluijk, PhD Candidate, University of Technology Eindhoven (TU/e), Eindhoven, Netherlands, n.sluijk@tue.nl, Joris Kinable, Wilco Van den Heuvel

We tackle a two-stage stochastic assignment problem obtained from a practical problem faced in postage sorting. In each stage, a subset of tasks Ti from T need to be assigned to agents in A, i=1,2. The tasks in T are in a specific order and are required to remain in that order when assigning them to the agents. This also holds for the tasks in T1 and T2 . The assignment made in the first stage restricts the solution space for the second assignment. The considered exact methods require exponential computation time, whereas the constructed heuristics result in near optimal solutions with shorter computation time. It is the required order of tasks that makes it a new and challenging topic for the OR community.

3 - **Online Job Shop Scheduling/Rescheduling Problem in Industry 4.0 Based Stochastic Environment Using Exact and Heuristic Optimization Methods**

Parsa Kianpour, Wichita State University, Wichita, KS, United States, pxkianpour@shockers.wichita.edu, Deepak Gupta

Scheduling in job shop environment is affected by multiple disruptions that need immediate actions. In these cases, the initial schedule may not be validated anymore. Therefore, imposed by industry 4.0 concept, this research studies the situation in which decisions are made in real time after revealing uncertain information. The performance of the rescheduling model is validated by evaluating the total cost (tardiness and earliness costs) with the goal of minimum deviation from the initial schedule using real data from local job shop. Multiple exact and heuristic approaches are studied to draw the solution for the optimization problem.

■ WC39

CC- Room 608

Vehicle Routing & Homeland Security

Contributed Session

Chair: Jorge E. Mendoza, HEC Montréal, 3000 Chemin de la Cÿte-Sainte-Catherine, Montréal, QC, H3T 2A7, Canada

1 - **Solving a Security Game in an Urban Road Network: An Evolutionary Approach**

Sukanya Samanta, Indian Institute of Technology Kharagpur, Kharagpur, India, ssukanya@iitkgp.ac.in, Goutam Sen, Soumya Kanti Ghosh

We consider a security game in a complex urban road network, in which the defender has multiple resources to mobilize in order to interdict an attacker who is trying to escape the city limits after committing a crime. This situation is prevalent in crimes such as kidnapping, robbery, trafficking, etc. and requires the law enforcement agency to deploy the resources optimally. We adopt a mixed-integer linear programming based double oracle approach to model the corresponding zero sum game. Since the optimal solution is not available for large instances, we develop a genetic algorithm to provide reasonably effective defender strategies and validate them on the dataset of the city of Kolkata, India.

2 - **A Three-agent Nonsequential Cybersecurity Game of Timing with Learning**

Arnab Bhattacharya, Staff Research Scientist, Pacific Northwest National Laboratory, Richland, WA, United States, Samrat Chatterjee, Shaunak Bopardikar

Strategic cyber-physical security interactions involve ideal timing of agent decisions to optimize offensive, defensive and operational objectives. We propose a stochastic optimization framework to analyze resilient defensive strategies that minimize the expected wait time of a legitimate user while maximizing expected time for a successful attack. We extend the state-of-the-art in security games of timing by considering 1) non-homogeneous arrival rate of adversarial threat vectors; 2) a legitimate system user with operational objectives; and 3) online learning of successful attacks. A notional case study with single and multiple assets is presented, and future research are identified.

3 - **A Scalable Routing Solution for Dynamic Border Apprehension Analysis**

Brandon P. Behlendorf, Assistant Professor, University at Albany, Albany, NY, United States, bbehlendorf@albany.edu

Irregular migration between ports of entry along the U.S.-Mexico border represents a critical challenge for border management. We present a novel simulation platform of generalized migration routes, using a scalable multimodal network coupled with static and user-generated weighting functions, to dynamically model cross-border flow across multiple resolutions. Results are weighed against historical apprehension data, and limitations of functional simulation modeling for front-line personnel are discussed.

4 - **Worst-case Analysis for a Leader-follower Partially Observable Stochastic Game and its Security Applications**

Yanling Chang, Texas A&M University, College Station, TX, United States, yanling.chang@tamu.edu

This research examines a leader-follower partially observable stochastic game where (i) the two agents are non-cooperative, (ii) the follower's objective is unknown to the leader, and (iii) the follower is possibly irrational. We determine the leader's optimal value function assuming a worst-case scenario on the basis of the knowledge of the leader. We analyze the structural properties of this value function and its computational complexity, and then design a viable and computationally efficient solution procedure . We illustrate the potential application of the proposed approach in a homeland security context.

5 - **Atari-ing the Vehicle Routing Problem with Stochastic Requests**

Jorge E. Mendoza, HEC Montréal, Montréal, QC, Canada, jorge.mendoza@hec.ca, Justin Goodson

Please check the mobile app for this abstract.

■ WC40

CC- Room 609

Optimization, Integer Programming II

Contributed Session

Chair: Nasibeh Zanjirani Farahani, University of Missouri, E3437 Thomas and Nell Lafferre Hall, Columbia, MO, 65211, United States

1 - **A Mixed Integer Programming Approach for Job Shop Scheduling with Sequence-dependent Setup Time and Tool Overheating Constraints to Minimize Makespan**

Juxihong Julaiti, Student, Penn State, State college, PA, United States, jpj5196@psu.edu

In a high-mixed and low-volume manufacturing facility, similar jobs are often scheduled together to decrease additional setup times. However, in dry machining processes, utilizing a tool for a prolonged period of time overheats the tool and increases chances of tool damage and scrapped parts. Therefore, the optimal schedule should avoid overheating while optimizing the objective function. To solve this issue, we propose a mixed integer programming model to minimize the makespan in a job-shop scheduling environment with sequence-dependent setup times and overheating constraints. Numerical studies are conducted to validate the model.

2 - **Penalty Variables and Multiobjective Optimization**

Ryan P. Kersh, IBM, Eugene, OR, United States, rkersh@us.ibm.com

With the CPLEX 12.9 release it is possible to define multiple objectives for a single problem. In this talk we will introduce a simplified definition of a penalty variable, and present a method for taking advantage of penalty variables with a multiobjective formulation. Finally, we will compare the performance of this method against default CPLEX.

3 - **Intermodal Freight Transportation Network Design for Super Loads**

Nasibeh Zanjirani Farahani, University of Missouri, E3437 Thomas and Nell Lafferre Hall, Columbia, MO, 65211, United States, Moein Enayati, James Noble

Commercial transportation will increase by 40% in the next 25 years, and the size of loads is supposed to be doubled in a decade. Planning of oversized cargo transportation can take a few months to over a year. For regular freights, the problem can be just finding the optimal route, but if the freight itself is oversize, overweight or non-regular, then feasibility and safety of shipment itself gets crucial. This research focuses on the routing of such loads by synchronizing the use of all modes of transportation as an option to reduce service time and cost.

4 - **SMD Optimization Problem Using MIP in Odd-type Component Environment**

Jae Wook Jeong, Korea Institute of Industrial Technology, Cheonan, Korea, Republic of, sage@kitech.re.kr, Hyunchul Tae, Young Hoon Lee, Jeongin Koo

In this paper, we try to reach the optimization by using mixed integer program (MIP) for SMD optimization problem in odd-type component environment. This MIP model has different results depending on each component, head and nozzle type. We aim to minimize the cycle time for nozzle change and head dropping components.

5 - **Probabilistic Minimum-cost Hamiltonian Cycle Problem Considering Vertex and Arc Failures**

Saeid Rasti, North Dakota State University, West Fargo, ND, United States, saeid.rasti@ndsu.edu

In this work we consider single tour and multiple tour probabilistic minimum-cost Hamiltonian cycle problem where there are success probability corresponding to vertices and arcs. The objective of this problem is finding the shortest tour in a way that the probability of reaching each nodes starting from origin be equal or greater than a specific threshold. for real life instances the solver is quiet slow, therefore we propose a branch-and-cut approach to tackle the complexity of the problem.

■ WC41

CC- Room 610

Joint Session OPT/Network/Practice Curated: Transportation Network Analysis

Sponsored: Optimization/Network Optimization

Sponsored Session

Chair: Bahar Cavdar, Middle East Technical University, Ankara, 06800, Turkey

1 - The Pickup and Delivery Problem with Online Transfers, for the Next Generation of Public Transport

Gizem Ozbaygin, Sabanci University, Faculty of Engineering and Natural Sciences, Istanbul, 34956, Turkey, Paul Bouman, Lucas Petrus Veelenturf

We introduce and study the pickup and delivery problem with online transfers, motivated by a passenger transportation concept involving self-driving vehicles, which can couple/decouple while en-route and transfer passengers seamlessly towards more efficient capacity utilization and traffic management. Among the major contributions of our study are: (1) development of an optimization based approach to solve a complex vehicle routing problem arising in an on-demand transportation system, (2) investigating the benefits of door-to-door shared mobility service with online transfers compared to private door-to-door rides, and shared mobility services with outside transfer possibilities.

2 - Dynamic Discretization Discovery for Service Network Design with Mixed Autonomous Fleets

Yannick Scherr, TU Braunschweig, University of Braunschweig, Braunschweig, Germany, y.scherr@tu-bs.de, Bruno Albert Neumann-Saavedra, Mike Hewitt, Dirk C. Mattfeld

In this service network design problem, a city logistics service provider seeks a repeatable plan to transport commodities from distribution centers to inner-city satellites. In a heterogeneous infrastructure, autonomous vehicles in SAE level 4 may drive in feasible streets but need to be guided elsewhere by manually operated vehicles in platoons. With our model, we determine a fleet mix, schedule transportation services, and decide on routing the commodities. We apply a dynamic discretization discovery algorithm that iteratively refines partially time-expanded networks, and we analyze its efficacy.

3 - A New Algorithm for School Bus Routing, Implementation in Boston

Sebastien Martin, Lyft, Cambridge, MA, 02139, United States, 92sebastien@gmail.com

We proposes an algorithm for school bus routing based on a novel decomposition approach. We also discuss the challenges of implementation. Our application in Boston led to $5 million in yearly savings (maintaining service quality despite a 50-bus fleet reduction).

4 - Traveling Repairman Problem on a Power Network

Bahar Cavdar, Middle East Technical University, Universiteler Mah, Dumlupinar Bulv, Ankara, 06800, Turkey, bcavdar@metu.edu.tr, Qie He, Feng Qiu

Power networks are often disrupted by various events interrupting electricity service. Many of these disruptions can only be recovered by physical attendance of the repair crew. In this study, we consider a power distribution network restoration problem with repair crew routing. We provide a formulation in a general form, and develop a problem-specific bi-directional Dynamic Programming solution approach.

■ WC42

CC- Room 611

Network Optimization Models in Ecology and Humanitarian Logistics and Natural Resources

Sponsored: Optimization/Network Optimization

Sponsored Session

Chair: Chao Wang, Arizona State University, Tempe, AZ

1 - Water Routing in River Networks

Berkin Arici, Jorge Seafair

River networks are large-scale complex systems characterized by nonlinear flow dynamics. Accurate representation of flows along a river—or routing—is crucial for flood control, reservoir management, and hydropower operations, among others. Muskingum models and their variants are vastly used in hydrology for water routing as they can incorporate physical parameters of the river basin. In this work, we introduce an MIP formulation to approximate the nonlinear Muskingum-Cunge equations. Our approach captures the nonlinear dynamics while providing a tractable description of water routing.

2 - Fireline Construction Optimization in a Heterogeneous Forest Landscape

Xu Yang, Northeastern University, Boston, MA, United States, yang.xu1@husky.neu.edu, Emanuel Melachrioudis

Firefighters attack a wildfire by constructing a fireline some distance from the fire perimeter. The decision of fireline path takes into account the fire's capacity to spread. We aim to find the shortest-in-time path for firefighting crews to build this fireline around the growing fire perimeter. The forest landscape is partitioned into homogeneous polygons. Nodes are selected on the polygon boundaries. These nodes are then connected in Delaunay triangulations to form a network of the forest landscape. A methodology is developed that uses a modified Dijkstra's algorithm to find the fastest, yet safest paths, for firefighting crews to finish the containment.

3 - Analysis of Algorithmic Alternatives for Optimizing and Planning Vaccine Distribution

Larissa P.G. Petroianu, PhD Candidate, University of Washington, Seattle, WA, United States, lpetroia@uw.edu, Zelda B. Zabinsky, Mauricio G. C. Resende, Mariam Zameer, Mamiza M. Muteia, Aida L. Coelho

Planning vaccine distribution is challenging in Mozambique rural and impoverished urban communities, due to inadequate vehicles, limited cold storage, road availability and weather conditions. Such constraints on vehicle routing for last mile delivery result in a mixed-integer optimization model that is computationally difficult to solve. We present a numerical study for a vehicle routing model for vaccine distribution to health facilities, where we compare standard optimization methods with an indexing algorithm on test problems, as well as three realistic data sets.

4 - Wildlife Corridor Design under Probabilistic Species Movement and Geometry Constraints

Chao Wang, Arizona State University, Tempe, AZ, United States, cwang198@asu.edu, Jorge Sefair

Habitat fragmentation jeopardizes species survival and reproduction. Current models for wildlife corridor design focus on the efficient allocation of resources under landscape constraints (e.g., land cost) but ignore animal movement. We present an alternative approach that accommodates landscape resistance features as well as other factors influencing movement (e.g., mortality). We introduce a discrete absorbing Markov chain approach to describe species movement in space and time. We embed this model into a mixed-integer programming formulation that decides the optimal set of patches to purchase to produce a corridor with the largest usage probability and a given width.

■ WC43

CC- Room 612

Joint Session ICS/Practice Curated: Political Redistricting

Sponsored: Computing

Sponsored Session

Chair: Hamidreza Validi, Oklahoma State University, Stillwater, OK, 74075, United States

1 - A Bisection Protocol for Political Redistricting

Ian G. Ludden, University of Illinois at Urbana-Champaign, Urbana, IL, United States, iludden2@illinois.edu, Rahul Swamy, Douglas M. King, Sheldon H. Jacobson

We introduce the bisection protocol, a fair division approach to political redistricting in which two players alternately divide pieces of the state in half (up to rounding) to obtain a district plan. The bisection protocol is compared to the I-cut-you-freeze protocol (Pegden et al. 2017) across standard fairness metrics. Computational experiments applying (mixed) integer programming formulations of the two protocols to several states provide further evidence of each protocol's merits and limitations. Our theoretical analyses and computational results can help each state make an informed decision of whether to adopt either protocol for congressional or state redistricting.

2 - Defining and Finding Impartial Districtings

Gerdus Benade, Carnegie Mellon University, Pittsburgh, PA, United States, Ariel Procaccia, John Hooker

We propose a notion of fairness that impartial districtings should satisfy and show that it is always possible to find a fair districting. This allows us to add fairness constraints to a novel recursive model for redistricting. Preliminary computational results show the promise of this approach.

3 - Imposing Contiguity Constraints in Political Districting Models

Hamidreza Validi, Oklahoma State University, Stillwater, OK, 74075, United States, Austin Buchanan, Eugene Lykhovyd

Beginning in the 1960s, techniques from operations research began to be used for political districting. A classical example is the integer programming model of Hess et al. (Operations Research 13(6):998-1006, 1965). The model of Hess et al. does not guarantee contiguity, requiring them to manually adjust their solutions to make them contiguous. In this work, we review some existing approaches for imposing contiguity in the Hess model, propose a new one, and analytically compare them in terms of strength and size. Finally, we conduct an extensive set of numerical experiments at the county and census tract levels to evaluate the different models' strengths and weaknesses.

4 - Extended Formulations for Simple Graph Partitioning on Sparse Graphs

Demetrios V. Papazaharias, University at Buffalo, Buffalo, NY, 14214, United States, dvpapaza@buffalo.edu, Jose Luis Walteros

The problem of simple graph partitioning is to partition the vertices of an edge weighted graph into mutually node-disjoint subgraphs, such that each subgraph contains no more than r nodes and the total weight of the edges connecting these subgraphs is minimized. Where most formulations define the variables over node-pairs in the graph, we seek to take advantage of the structure of sparse graphs by defining our variables over the edges. We will discuss several extended formulations, a dynamic program for this problem which we will use as a separation algorithm on general graphs, and provide some insight on the valid inequalities of our formulations.

■ WC44

CC- Room 613

Recent Advances in Learning and Distributionally Robust Optimization II

Sponsored: Computing

Sponsored Session

Chair: Hamed Rahimian, Northwestern University, Evanston, IL, 60208, United States

1 - Minimax Statistical Learning with Wasserstein distances

Jaeho Lee, KAIST, Daejeon, Korea, Republic of, jaeho-lee@kaist.ac.kr

Jaeho Lee, UIUC, Urbana, IL, United States, jaeho-lee@kaist.ac.kr

We describe a minimax framework for statistical learning with ambiguity sets given by balls in Wasserstein space, and prove generalization bounds for the distributionally robust optimization counterpart of the standard empirical risk minimization procedure. As an illustrative example, we provide generalization guarantees for transport-based domain adaptation problems where the Wasserstein distance between the source and target domain distributions can be estimated from unlabeled samples. This is a joint work with Maxim Raginsky.

2 - Designing Performance-aligned Learning Algorithms Using Distributionally Robust Principle

Rizal Fathony, Carnegie Mellon University, Pittsburgh, PA, United States, rfathony@cs.cmu.edu

The goal of many prediction tasks in machine learning is to learn a prediction function that minimizes certain loss metrics (e.g., zero-one, ordinal, and cost-sensitive loss) or maximizes certain performance metrics (e.g., accuracy, precision, and F1-score) on the testing dataset. We present a new technique for designing learning algorithms for these tasks using distributionally robust principle where the uncertainty sets are defined over the predictive distributions. We demonstrate the theoretical and practical benefits of our approach in a range of prediction tasks including multiclass classification, ordinal regression, structured prediction, and graphical models.

3 - Accelerating Convergence in Wasserstein Distance in High Dimensions

Shashank Singh, Carnegie Mellon University, Pittsburgh, PA, United States, sss1@andrew.cmu.edu

Many methods for distributionally robust optimization and learning rely on convergence of the empirical distribution of n IID samples to their population distribution P in mean Wasserstein distance, as n increases. For d-dimensional data, this convergence can be as slow as O(n-1/d), prohibitively slow for even moderate d. Several recent papers have shown convergence much faster than O(n-1/d) under mild additional assumptions on P. We discuss faster rates when the data have low intrinsic dimension, the data distribution is smooth, or Wasserstein distance is replaced by one of many distances that are weaker but retain distributional robustness properties motivating Wasserstein distance.

■ WC45

CC- Room 614

Nonconvex Optimization

Sponsored: Optimization/Nonlinear Programming

Sponsored Session

Chair: Nuri Denizcan Vanli, Massachusetts Institute of Tehnology, Cambridge, MA, 02141, United States

Co-Chair: Asuman Ozdaglar, Massachusetts Institute of Technology, Cambridge, MA, 02139, United States

1 - Solving Large Scale SDPs via Block-Coordinate Maximization Burer-Monteiro Approach

Nuri Denizcan Vanli, Massachusetts Institute of Tehnology, Cambridge, MA, 02141, United States, denizcan@mit.edu

We prove that the block-coordinate maximization algorithm applied to the non-convex Burer-Monteiro approach globally converges to a first-order stationary point with a sublinear rate. We also show that the block-coordinate maximization algorithm is locally linearly convergent to a local maximum under local weak strong concavity assumption. We establish that this assumption generically holds when the rank of the factorization is sufficiently large. Furthermore, we propose an algorithm based on the block-coordinate maximization and Lanczos methods that is guaranteed to return a solution that provide $1-\O{1/r}$ approximation to the original SDP, where r is the rank of the factorization.

2 - Analysis of a Two-layer Neural Network via Displacement Convexity

Adel Javanmard, University of Southern California, Los Angeles, CA, 90089, United States, Marco Mondelli, Andrea Montanari

We consider the problem of learning a function defined on a compact domain, using linear combinations of a large number of "bump-like" components (neurons). This idea lies at the core of a variety of methods from two-layer neural networks to kernel regression, to boosting. The parameters to be fitted are the centers of the bumps, and the resulting risk minimization problem is highly non-convex. We prove that in the limit in which the number of neurons diverges and the bump width tends to zero, the gradient flow has a limit which is a viscous porous medium equation. By virtue of a property named "displacement convexity", we show exponential dimension-free convergence rate for the gradient descent.

3 - Distributionally Robust Optimization and Generalization in Kernel Methods

Matthew Staib, Massachusetts Institute of Technology, Cambridge, MA, 02139, United States, Stefanie Jegelka

Distributionally robust optimization (DRO) enjoys connections to regularization, generalization, and robustness in machine learning. Work so far considered uncertainty sets based on f-divergences and Wasserstein distances, which have drawbacks. We study DRO with maximum mean discrepancy (MMD) uncertainty sets. We show that MMD DRO is roughly equivalent to regularization by the Hilbert norm. As a byproduct, we obtain an alternative generalization proof for Gaussian kernel ridge regression via a new DRO lense. Beyond kernel methods, we derive a generically applicable approximation of MMD DRO, and show that it generalizes recent work on (non-convex) variance-based regularization.

4 - Unique Sink Orientations for Homogeneous Linear Inequalities and Their Alternative Systems

Jourdain Lamperski, MIT, Cambridge, MA, United States, jourdain@mit.edu

We reduce the problem of computing a solution to a homogeneous system of linear inequalities to the problem of computing the unique sink of a certain unique sink orientation (USO). We address a question of Morris (2002) and Jaggi (2006) by showing that the USO satisfies a local property that is not satisfied by all USOs that satisfy the Holt-Klee property, raising the question of whether the local property can be leveraged algorithmically to develop faster algorithms or a strongly polynomial algorithm.

■ WC46

CC- Room 615

Advances in Estimation and Control for Intersections

Sponsored: Transportation Science & Logistics/Intelligent Transportation Systems (ITS)

Sponsored Session

Chair: Saif Eddin G Jabari, New York University, Abu Dhabi, United Arab Emirates

1 - A Data Fusion Approach to Traffic State Estimation

Yan Zhao, University of Michigan, Ann Arbor, MI, 48104, United States, zhaoyann@umich.edu, Xintao Yan, Henry Liu

The emergence of connected vehicle technology and ride-hailing services has enabled the collection of probe vehicle trajectory data in large scale. The newly available trajectory data and the existing fixed-location sensor data could be combined for better traffic condition monitoring and transportation network evaluation. This study proposes a data fusion approach to traffic state estimation based on matrix factorization. Validation results have shown that the proposed method could significantly improve the estimation accuracy compared to traditional methods.

2 - A Decentralized Control Approach Using Kinematic Traffic Theory

Li Li, New York University, New York, NY, United States, ll3252@nyu.edu, Saif Eddin G. Jabari

This paper derives a position weighted backpressure (PWBP) control policy for network traffic applying continuum modeling principles of traffic dynamics and thus capture the spatial distribution of vehicles along network roads and spill-back dynamics. We conduct comparisons against a real-world adaptive control implementation for an isolated intersection. Comparisons are also performed against other BP approaches in addition to optimized fixed timing control at the network level. These experiments demonstrate the superiority of PWBP over the other control policies in terms of capacity region, network-wide delay, congestion propagation speed, and response to incidents.

3 - Reinforcement Learning Based Traffic Signal Control

Xuegang Ban, University of Washington, Seattle, WA, United States, banx@uw.edu, Qiangqiang Guo

As the rise of Connected and Automated Vehicles (CAV), it becomes practical to train learning-based methods to better control traffic signals by utilizing CAVs' data. Reinforcement learning (RL) has shown great promise in agent-based interactive optimal control. Current RL based signal control methods usually assume full CAV penetration and simplify the intersection scenario to reduce the action space, which make these methods not practical. This paper proposes a new RL based signal control algorithm based on a real-world eight-phase intersection and study the control performance under limited CAV penetrations. The control performance is analyzed through numerical experiments.

4 - Virtual Platooning Control for Cooperative Intersection Crossing of Connected Autonomous Vehicles

Xiaozheng He, Rensselaer Polytechnic Institute, Troy, NY, 12180, United States, hex6@rpi.edu, Yu Wei

This study proposes a virtual platooning control mechanism to facilitate the cooperative intersection crossing of connected and autonomous vehicles (CAVs), where the approaching CAVs on different links are mapped into one platoon to support cooperated behavior. To ensure the safety of cooperative crossing, we analyze the virtual platooning stability by factoring information spread into the modeling and considering the influences of communication delay on virtual platooning. Simulation experiment results demonstrate the efficiency of the proposed control mechanism.

■ WC47

CC- Room 616

Transportation, Planning I

Contributed Session

Chair: Hossein Nasr Esfahani, Utah State University, Logan, UT, 84341, United States

1 - Electric Charging Infrastructure Deployment the Past the Present and the Future

Tara Radvand, Research Assistant, Purdue University, West Lafayette, IN, United States, tradvand@purdue.edu, Mohammad Miralinaghi, Samuel Labi, Majed Alinizzi

There is a growing body of literature on optimal strategies for electric vehicle (EV) infrastructure deployment. As such, a comprehensive review of the literature is helpful to understand the current research trajectory. This talk focuses on two aspects related to charging infrastructure deployment. The first aspect is related to recent technological progress of EVs and the wireless and battery charging mechanisms. The second aspect is related to human factors such as range anxiety. The talk classifies the various solution methodologies that have been used to obtain the optimal strategies. Finally, the talk discusses the necessary future research directions to enhance the deployment process.

2 - Evaluation of Railway Hub Logistics System Scheme by Taking a Hub in China as an Example

Tao Chen, National and Local Joint Engineering Laboratory of Comprehensive Intelligent Transportation, Southwest JiaoTong University, Chengdu, China, swjtuchentao@qq.com, Boer Deng, Shaoquan Ni, Ran Li

The construction of China's railway hub logistics system has many influence factors and high costs, so it has social and economic significance to evaluate its planning scheme. This study has obtained experience from a large number of hub planning schemes, and sets up an total of 29 indicators in the macro, meso and micro levels, using the method of AHP, and proposed two index combinations for different objects: system planning and station planning evaluation. By using the improved fuzzy-grey comprehensive evaluation method to construct a model, the evaluation software was designed. Then, taking the Hefei hub in China as an example to evaluate, the final results were in line with reality.

3 - A Link Criticality Index Embedded in Iterative Solutions of User Equilibrium Traffic Assignment

Amirmasoud Almotahari, Stony Brook University, Stony Brook, NY, United States, am.almotahari@stonybrook.edu, Anil Yazici

Due to non-linearity of link performance functions in road networks, researchers select a network performance measure, remove links one-by-one, and reassigned traffic demand to calculate the impacts of each link failure. In this study, the user equilibrium formulation is utilized, and two iterative solutions (Frank-Wolfe and Gradient Projection) are exploited to identify link criticality ranking within a single traffic assignment. The developed criticality measure is compared with selected measures through numerical examples. The results indicate the proposed measure better deliberate criticality in terms of connectivity/redundancy as well as the traffic conditions in the network.

4 - Large-scale, Unconstrained Multiple Vehicle Routing Problem Using Two-Phase Assignment Approach

Joon-yeoul Oh, Associate Professor, Texas A&M University-Kingsville, Kingsville, TX, United States, kfjo000@tamuk.edu, Shivani Nilkanth Patil, Amir Hessami, David Hicks

A well planned routing can reduce transportation costs but planning an efficient routing can be complex and time consuming for a larger number of nodes to visit. This research presents an efficient yet effective algorithm for a large scale, unconstrained multiple vehicle routing problem, using a two phase grouping assignment technique. To test the practicability of the proposed algorithm, various cases are created and compared with the outputs of K means clustering algorithm. The results of the cases show that the two phase assignment technique has performed very well with average 10% better route distance and average 55% faster elapsed time than the K means clustering algorithm.

5 - understanding the Impacts of Wireless Charging and Dedicated Autonomous Vehicle Lanes on Autonomous Vehicle Adoption and Vehicle Fuel Type Choice

Yuntao Guo, Purdue University, West Lafayette, IN, United States, gyt861211@gmail.com, Dustin Souders, Irina Benedyk, Srinivas Peeta, Samuel Labi

This study investigates the potential impacts of wireless charging and dedicated autonomous vehicle (AV) lanes on travelers' willingness to use, buy, and pay for Level 4 AVs and on their choice of vehicle fuel type (gasoline-powered and all-electric). The study uses stated preference survey data. The results can potentially facilitate the development of road network design guidelines and policies, and can aid roadway agencies in planning the built environment to facilitate AV adoption.

6 - Path-Constrained Flow-Dependent Reliability-Based Traffic Assignment of Battery Electric Vehicles Considering Stochastic Rance Anxiety

Hossein Nasr Esfahani, Utah State University, Logan, UT, United States, hosseinnasr1368@yahoo.com, Ziqi Song

This study addresses the reliability-based equilibrium traffic assignment problem of battery electric vehicles (EVs) with flow-dependent stochastic energy consumption. To capture the impact of travel time uncertainty on EVs energy consumption, a model is presented with flow-dependent reliability-based path-constraints, which minimizes drivers' travel cost by reducing the weighted summation of total travel time and energy consumption plus their uncertainties. The result demonstrates a better explanation of EV drivers' different route choice decisions, such as willingness to remain in urban areas.

■ WC48

CC- Room 617

Signal-free Traffic Control in Connected and Automated Vehicle Environment

Sponsored: Transportation Science & Logistics/Intelligent Transportation Systems (ITS)

Sponsored Session

Chair: Leila Hajibabai, North Carolina State University, Raleigh, NC, United States

1 - Trajectory Optimization of Connected Self-Driving Vehicles at Roundabouts

Rasool Mohebifard, Washington State University, WA, 99163, United States, Ali Hajbabaie

This study formulates trajectory control of connected self-driving vehicles (CSVs) in roundabouts as a non-linear and non-convex optimization program. The program minimizes the total travel time of CAVs and includes vehicle dynamics and collision-avoidance constraints with explicit representation of vehicles paths. We introduce a customized solution technique that convexifies the collision-avoidance constraint and employs the Alternating Direction Method of Multipliers to decompose the convexified problem into two sub-problems.

2 - Max-pressure Based Autonomous Intersection Management with Pedestrians

Rongsheng Chen, University of Minnesota, Minneapolis, MN, United States, mlevin@umn.edu, Jeffrey Hu, Michael Levin

Autonomous intersection management (AIM) can drastically reduce delays for automated vehicles, but pedestrian access to AIM has yet to be addressed. This study proposes an AIM algorithm that integrates the existing trajectory planning algorithm with max-pressure control, which aims to maximize the combined vehicle and pedestrian throughput of the network. A linear program is formulated to calculate the optimal intersection control strategy based on vehicle and pedestrian queues lengths (pedestrian queues are estimated). To evaluate the impacts of pedestrians on vehicle queue lengths and delays, this study runs simulations under different combinations of pedestrian and vehicle demands.

3 - Scheduling of Heterogeneous Connected Automated Vehicles at a General Conflict Area

Xiaopeng Li, University of South Florida, Tampa, FL, 33620, United States, xpli02@gmail.com, Saeid Soleimaniamiri

Allocating time for vehicles arriving at a general conflict area to pass without collision is a common problem in traffic operations at various facilities, such as intersections, work-zones, and merging ramps. With the advent of connected automated vehicle (CAV) technologies, vehicle scheduling at a conflict area can be precise to each individual vehicle, which enables studies on a number of individual-vehicle based control strategies at various conflict areas. This research aims to address the research gaps in both fundamental methodologies and engineering applications on this general topic.

4 - Cooperative Roundabout Throughput Strategies for Connected Autonomous Vehicles

Chaojie Wang, Gatech, Atlanta, GA, United States

We propose cooperative roundabout passing throughput strategies for connected autonomous vehicles (CAVs) to enhance roundabout traffic flow performance in roundaboutse by coordinate coordinating the incoming flows into a virtual platoon. An optimization model is established to determine the optimal virtual platoon that can maximize roundabout performance based on one or more objectives (roundabout throughput, smoothness and robustness of the virtual platoon). The effectiveness and efficiency of the proposed strategies for CAV platoons will be illustrated using numerical simulation and compared with those of signalized intersections.

■ WC50

CC- Room 619

Bayesian Approach

Contributed Session

Chair: Babak Zafari, Babson College, MA, 02457, United States

1 - Spatio-temporal Analysis of Water Pipe Failures Using a Bayesian Network

Jared Beekman, Analyst, Innovative Decisions, Inc., Vienna, VA, United States, jbeekman@innovativedecisions.com, Craig Daly, Kate Zhao, Sepideh Yazdekhasti, Thomas Chen, Dennis Buede

We investigate the applicability of Bayesian Networks for classifying water pipe failures using spatio-temporal variables across several US utilities. Bayesian Networks illustrate probabilistic relationships that are mathematically rigorous and intuitively understandable, providing sound statistical principles for evaluating primary causal factors driving water pipe failures. This research addresses utilities' decision-making needs in prioritizing repair and replacement of deteriorating water pipe infrastructure.

2 - Bayesian Estimation of Inventory Counts

Thomas Gartner, Starbucks, Seattle, WA, United States, Renaud Lecoeuche

How can Bayesian estimation techniques be applied to more accurately process real life inventory counts? In order to automatically send a retail store the appropriate quantity of any good, knowing what they have today is essential. We present a Bayesian particle filtering approach to process thousands of hand-counted inventory estimations that are highly prone to human error, for use in an automated ordering system at Starbucks.

3 - Forecasting the Real Gas Price with BVARS: The Role of Temperature

Arthur Thomas, IFP Energies nouvelles / University of Nantes, Rueil-Malmaison, France, arthur.thomas@ifpen.fr, Benoît Sévi, Zakaria Moussa

Using some hand-collected data from the monthly energy review dating back to 1997, a monthly real-time dataset is constructed to generate forecasts of natural gas prices as established at the Henry Hub. We compare the performance of a variety of models including state-of-the-art Bayesian and time-varying-parameters (TVP) models. Considering extensions to possible structural breaks, non-Gaussian distributions and variable selection along with volatility models, we provide evidence that Bayesian and TVP models help in forecasting the real price of natural gas for horizons up to one year.

4 - Predicting Daily Power Outages Using a Fair Bayesian Model Averaging Approach

Elnaz Kabir, University of Michigan, Ann Arbor, MI, United States, ekabir@umich.edu, Seth Guikema

A wide variety of weather conditions, from wind storms to prolonged heat events, can have substantial impacts on power systems, posing many risks and inconveniences due to power outages. Being able to estimate the number of customers without power based on a weather forecast has the potential to help utilities restore power more quickly and efficiently. In this study, we apply Bayesian Model Averaging (BMA) to form an ensemble model estimating the probability distribution of daily customer outages. The model is trained using historic outage and weather data and based on an iterative statistical process.

5 - Using Natural Language Processing Models for Anomaly Detection: A Case of Medical Data

Babak Zafari, Babson College, Babson Park, MA, United States, bzafari@babson.edu

In this work, we present novel solutions on using natural language processing models for anomaly detection. We demonstrate the process by applying it to healthcare data; more specifically medical prescription data. The size and complexity of the healthcare systems as well as the cost of medical audits make use of statistical methods necessary to generate investigative leads in prescription audits. Our proposed methods offer probabilistic information of prescription patterns of providers and can reveal hidden patterns which can lead to discovery of potential cases of drug diversion.

■ WC51

CC- Room 620

Joint Session AAS/TSL Air: Evidence Based Empirical Studies of Airline Operations

Sponsored: Aviation Applications

Sponsored Session

Chair: Farbod Farhadi, Roger Williams University, Bristol, RI, 02809, United States

Co-Chair: David F Pyke, University of San Diego, San Diego, CA, 92110-2492, United States

1 - The Impact of Fight Outsourcing Policies in the U.S. Air Transport Industry

David F. Pyke, University of San Diego, Coronado 108, 5998 Alcala Park, San Diego, CA, 92110-2492, United States, davidpyke@sandiego.edu, Farbod Farhadi, Soheil Sibdari, Matthew Gregg

We study the impact of regional airline market share on average airfares and flight frequencies, by constructing a 20-year panel of U.S. airport-level data. Our results suggest that increases in regional airline market shares increase both average fares and flight frequencies at the airport level. Less connected airports and shorter distance flights seem to be the drivers of the flight outsourcing decisions. We further investigate these effects before and after the 2007 U.S. economic recession and show how the impact on airfares and flight frequencies vary across years.

2 - Market Selection Strategies of Regional Carriers in the U.S.

Farbod Farhadi, Roger Williams University, Bristol, RI, 02809, United States, ffarhadi@rwu.edu, Soheil Sibdari, David F. Pyke

Regional carriers play a major role in the U.S. domestic air transport industry. They operate flights from low demand destinations to larger airports creating a complementary network of routs that feeds the hub and spoke operations of the major carriers. In this study we analyze the market selection strategies of regional airlines within the U.S. domestic air transportation network.

3 - Do Employee Labor Constraints Raise Product Quality? Empirical Evidence from U.S. Airlines

Kerry Tan, Loyola University Maryland, Baltimore, MD, United States, kmtan@loyola.edu, Nicholas Rupp

Legislation H.R. 5900, approved in August 2010 and effective in August 2013, implemented more restrictive pilot rest requirements and increased the number of pilot training hours required (now 1,500 hours) to obtain a pilot license. This paper examines the effect of raising the safety standards on airline service quality. A priori, the effect is ambiguous since putting in place more restrictive requirements on labor gives a company less flexibility in managing its resources which suggests a detriment to on-time performance. On the other hand, well-rested pilots with greater experience may provide enhanced productivity for their employer which may lead to improved on-time performance.

4 - Airline Delays and Market Power

Paulos Lakew, Unison Consulting, Inc., Mission Viejo, CA, United States, Volodymyr Bilotkach

This study uses aggregated data on concentration, delays, and airfares from US airports to shed light on two issues. First, we examine the concentration-delays relationship to contribute to the airport-congestion self-internalization debate. Our study is the first investigation of this issue that uses data on sources of delays. Second, we evaluate whether increases in flight delays result in lower airfares. Our empirical results are mixed: while total delays are positively correlated with airport-level concentration (contradicting the self-internalization hypothesis), the variance of delays at larger airports falls as concentration increases.

■ WC52

CC- Skagit 1

Forecasting III

Contributed Session

Chair: Renzo Benavente, Pontificia Universidad Catolica del Peru, Velez Robles, 180, Lima, LIMA 09, Peru

1 - Statistical Analysis of Functional Data and its Application in the Study of PM10 in Bogotá, Colombia

Sebastián F. Calcetero, Lecturer, Universidad de los Andes, Bogotá, Colombia, sf.calcetero674@uniandes.edu.co, Maria Elsa Correal

The objective of this project is, on one hand, to describe some relevant concepts of functional data analysis, including some quantitative strategies developed to analyze statistically; and on another hand, to illustrate its application in the understanding of PM10 in Bogotá, and discuss its usefulness in the development of air pollution policies. Specifically, we use the approach of functional principal components to estimate multiple functional regression models, functional autoregressive moving average models, and introduce the innovate idea of functional dynamic regression models.

2 - How to Set Up a Race Between 16 Predictive Algorithms and Still Win

Kellington Neves, FICO, San Diego, CA, United States, kellingtonneves@fico.com

Come to learn how FICO analytics professionals worked with Grupo Fleury, one of the largest diagnostic medicine companies in Brazil, to develop a complete demand planning management platform. FICO® Forecaster now allows them to accurately predict their sales forecast using 16 different complex forecasting methods complemented by business knowledge, to perform management analyzes of past forecasts to help improve future forecasts, to estimate their unrestricted demand and know the potential sales that they could realize, and reduce their costs through more efficient resource allocation.

3 - One Step-ahead Predictive Ability in Nested Regression Models

Silu Lyu, Washington State University, Pullman, WA, United States, silu.lyu@wsu.edu, Stergios Fotopoulos

Our paper researches on how to make model selection considering the predictive ability in the case of overfitting. This can be an analytical tool for econometric models for a large quantity and high-dimensional data. We start with measuring the one-step-ahead predictive accuracy. Next, we develop a test hypothesis analysis to determine which model is better in terms of predictive accuracy. Simulations results confirm that the empirical approximated statistics is a function of the in-sample ratios, and the terms omitted are shown to be negligible. Also, power tests and goodness-of-fit tests are developed. Finally, three stocks from high-tech are considered to illustrate the proposed methodology.

4 - Demand Forecasting Using Subjective Rankings

Marat Salikhov, INSEAD, Singapore, Singapore, marat.salikhov@insead.edu

Please check the mobile app for this abstract.

5 - Predictive Model for a Contact Center in a Latin American Bank

Renzo A. Benavente, Pontificia Universidad Catolica del Peru, Lima, Peru, renzo.benavente@pucp.pe, Jonatan Rojas, Miguel Rodriguez

This research aims to predict incoming reclaims calls at the contact center of a Latin American bank. Significant variables that influence the number of calls entered in the period 2015 to 2018 were identified. Then the data was trained in this period with models Random Forest, Time Series, Neural Network and then the one with the best fit was chosen. With the chosen model, the months January and February of 2019 were projected, which then, when compared with the real data, had a MAPE of 4%. Comparing with the previous method of prediction that the bank had, it saved 8% in personnel costs in these 2 months of validation.

■ WC53

CC- Skagit 2

Marketplaces

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Xuanming Su, University of Pennsylvania, University of Pennsylvania, Philadelphia, PA, 19104, United States

Co-Chair: Jaelynn Oh, University of Utah, Salt Lake City, UT, 84112, United States

1 - Can Delivery Platforms Benefit Restaurants?

Andrew E. Frazelle, The University of Texas at Dallas, 4719 COLE AVE APT 324, Richardson, TX, 75205, United States, andrew.frazelle@utdallas.edu

In the restaurant industry, delivery platforms collect customer orders via web-based systems, transmit them to restaurants, and deliver the orders to customers. We investigate this business model, and answer the following question: can delivery platforms benefit restaurants? We conclude that the most common contract, one-way revenue sharing, has inherent drawbacks, but these can be partially mitigated by an even simpler relationship with no formal contractual agreement between the delivery platform and the restaurant.

2 - Strategic Data Sharing in Networks

Ilan Morgenstern, Stanford University, Stanford, CA, United States, ilanmor@stanford.edu, Kostas Bimpikis, Daniela Saban

We consider a setting in which competing firms may use information they derive from past transactions to price discriminate their customers. Anticipating this, customers may have the incentive to delay or altogether forgo transacting with a firm. We establish that customers' "privacy concerns" may lead to price dispersion, even in a perfectly competitive market. We also discuss the welfare implications and explore potential interventions aimed at increasing overall surplus.

3 - Labor Welfare in On-demand Service Platforms

Saif Benjaafar, University of Minnesota, Department of Industrial and Systems Engr, Minneapolis, MN, 55419, United States, saif@umn.edu, Jian-Ya Ding, Guangwen Kong, Terry Taylor

The lack of regulatory protections granted to "gig-economy" workers, coupled with the growing number of these workers, has prompted labor advocates and regulators to consider measures aimed at improving the welfare of these workers: measures that limit the labor pool size or impose a floor on the nominal wage or effective wage. This paper characterizes the effect of such measures on average labor welfare. We characterize when efforts to limit the labor pool size are counterproductive, and we provide a sharp prescription for the type of wage floor to impose.

4 - Pricing Models for Online Food Delivery

Jaelynn Oh, University of Utah, Salt Lake City, UT, 84112, United States, jaelynn.oh@business.utah.edu, Xuanming Su, Chloe Kim Glaeser

Online food delivery platforms connect restaurants with customers and deliver food to their door. In return, the platform charges restaurants a commission rate and charges customers a delivery fee. We study best pricing practices for the platform, partnering restaurants, and customers using game-theoretic models.

■ WC54

CC- Skagit 3

Joint Session RMP/Practice Curated: Practical Approaches in Solving Large-scale Revenue and Pricing Optimization Problems

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Ang Li, PROS, Inc., PROS, Inc., Houston, TX, 77002, çUnited States

1 - Sales Promotion Strategies for Substitutable and Seasonal Products with an Application to a Leading Chain Supermarket in China

Su Zhao, Ainnovation, Beijing, China, zhaosu@ainnovation.com, Xuanqi Zhang, Xiang Liu

In this presentation, firstly, a machine learning engine including top performing algorithms is designed to predict sales of product categories for a flexible time period, with top sales and high price elasticity categories generated. Then sales promotion strategies for substitutable products within categories targeting at an overall profit maximization are provided using dedicated cross product elasticity analysis. Furthermore, promotion strategies for perishable or seasonal products applying with dynamic programming over finite selling periods are suggested and have been compared with the current supermarket operational results.

2 - Optimizing Customer Stimuli in a Casual Dining Context

Jose Luis Preciado Arreola, Assistant Professor, Tecnologico de Monterrey, Monterrey, Mexico, jlpreciadoarreola@tec.mx

We explore customer susceptibility to consume augmented bundles of products as linked to their satisfaction with their experience in a casual dining setup. Specifically, we link customer satisfaction survey results to transaction KPIs at a gourmet burger chain. We then conduct controlled offering/service experiments to assess the customers' marginal propensity to modify their buying patterns in the same direction as the offering. We then use these results to perform offer optimization on a revenue basis, accounting for cannibalization across offerings. Statistical techniques involved include ensembled nonparametric regression, text mining, A/B testing and Mixed-Integer Programming.

3 - Revenue Management for Vacation Homes

Anurag Verma, PriceLabs, Chicago, IL, United States, anurag@pricelabs.co, Pedro Borges

Revenue management for vacation homes is complicated due to a few reasons: 1) Each vacation home is a unique product, and can't be compared to other homes directly; 2) Unlike hotels (multiple rooms) or airlines (multiple seats), there is only one home to be sold on any given night, which makes booking pace impossible to gauge (for any future date, you're either completely booked or not booked at all); 3) Given the small inventory, historic data can be noisy, 4) Supply and demand fluctuates a lot from one year to the next. We discuss what these challenges mean and how revenue management frameworks from hotels and airlines have been adapted to work well in this new(ish) travel segment.

4 - Competitive Rm Models with Loyal and Fully Flexible Customers

Wei Wang, PROS Inc, 3100 Main St, Suite #900, Houston, TX, 77002, United States, weiwang@pros.com, Ravi Kumar, Darius Walczak, Ahmed Simrin, Sivarama Arunachalam

Competition in the Airline RM is a topic that has been long talked about and various ways of accounting for competition have been invented. The microeconomics models of competition have been of lesser value since many of their assumptions were deemed unrealistic. One of those assumptions is to treat all customers as seeking the lowest price in the market. On the other hand almost all early RM models assumed that demand is dedicated to an airline. We show realistic competitive RM models including both those types of customers. Furthermore, we show the same idea apply not only in the existing fare class-based world but also within the classless dynamic pricing context and present numerical examples for both.

5 - A Few Practical Treatments on Optimizing Pricing on a Large Bus Network

Ang Li, PROS, Inc., Houston, TX, 77002, United States, ali@pros.com, Manu Chaudhary

We present an LP formulation that determines pricing and capacity allocation for all passenger demands over a large bus network. Due to the sheer size of our problem, several treatments were made to meet practical run-time requirements. Among these, we will discuss a theme to solve the model in chunks, and utilization of dual values and certain unconstrained-revenue-optimal prices for itineraries that do not receive demand allocation.

■ WC55

CC- Skagit 4

Seeding and Value of Network Information in Social Network Applications

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Amin Rahimian, MIT Institute for Data, Systems and Society, Cambridge, MA, 02142, United States

Co-Chair: Ankur Mani, University of Minnesota, Saint Louis, MO, 63108-2432, United States

1 - Seeding with Costly Network Information

Amin Rahimian, MIT Institute for Data, Systems and Society, Cambridge, MA, 02142, United States, rahimian@mit.edu, Dean Eckles, Hossein Esfandiari, Elchanan Mossel

Seeding the most influential individuals based on the contact structure can substantially enhance the extent of a spread over the social network. Most of the influence maximization literature assumes the knowledge of the entire network graph. However, in practice, obtaining full knowledge of the network structure is very costly. We propose polynomial-time algorithms that provide almost tight approximation guarantees using a bounded number of queries to the graph structure. We also provide hardness results to bound the query complexity and show tightness of our guarantees.

2 - Evaluating Stochastic Seeding Strategies in Networks

Dean Eckles, MIT, Cambridge, MA, 02142, United States, Alex Chin, Johan Ugander

It is common to strategize about where in a network to seed a behavior, often with an element of randomness. One stochastic strategy, one-hop targeting, is to select random network neighbors of random individuals; this exploits a version of the friendship paradox. Here we show how stochastic seeding strategies can be evaluated more efficiently, how they can be evaluated "off-policy" using existing data arising from experiments designed for other purposes, and how to design more efficient experiments. The proposed estimators and designs can dramatically increase precision. We then apply our proposed estimators to two field experiments.

3 - Think Globally, Act Locally: on the Optimal Seeding for Nonsubmodular Influence Maximization

Fang-Yi Yu, University of Michigan, Ann Arbor, MI, United States, fayu@umich.edu, Grant Schoenebeck, Biaoshuai Tao

We study the r-complex contagion influence maximization problem. In the r-complex contagion model, each vertex becomes infected if it has at least r infected neighbors. We focus on the stochastic hierarchical blockmodel, a special case of stochastic blockmodel. We prove that, under certain mild assumptions, putting all the seeds in a single community is the optimal seeding strategy. This matches the intuition that it is beneficial to put seeds near each other to maximize their synergy in a non-submodular cascade model, which is in sharp contrast to the seeding strategy in submodular cascade models. Finally, we show that this observation yields a polynomial time dynamic programming algorithm.

4 - The Impact of Network Structure on Price Discrimination

Jiali Huang, University of Minnesota, Minneapolis, MN, 55414, United States, Ankur Mani, Zizhuo Wang

We study the problem of a single seller that can potentially use social network information to provide personalized prices to customers based on their network positions. We show that in large random networks with general degree distributions, the gain in profit under such discriminative pricing (as compared to uniform pricing) depends greatly upon the network structures, and the gain in profit might not be significant. For types of networks with significant gain in profit from discriminative pricing, we propose simple implementable pricing policies that are robust against noisy observations in the networks.

5 - Efficient Polling and Estimation Methods that Exploit Friendship Paradox

Buddhika Nettasinghe, Cornell University, Ithaca, NY, 10044, United States, Vikram Krishnamurthy

We consider the problem of forecasting the outcome of an election between two candidates A and B. We propose a novel neighborhood expectation polling (NEP) strategy that asks randomly sampled individuals: "what is your estimate of the fraction of votes for candidate A?". Hence, in NEP, sampled individuals will naturally look at their neighbors (defined by the underlying network) when answering this question. Hence, the mean squared error (MSE) of NEP methods rely on selecting the optimal set of samples from the network. To this end, we propose algorithms that exploit friendship paradox for selecting samples. Results on the dependence of the MSE of the algorithms on the network properties are presented.

■ WC56

CC- Skagit 5

Operations Management/Marketing Interface III

Contributed Session

Chair: Justus Arne Schwarz, University of Mannheim, Schloss Schneckenhof Ost, Mannheim, 68131, Germany

1 - Online Order Fulfillment with Strategic Customers

Chao Liang, Cheung Kong Graduate School of Business, Beijing, China, cliang@ckgsb.edu.cn, Yuxin Chen

We study where an e-tailer should store inventory to fulfill online order: store inventory in local warehouse so the shipping cost (to customer place) is low while the holding cost is high, store inventory in central warehouse so the shipping cost is high but the holding cost is low, or store the inventory in both warehouses. We find that the firm should keep at least some (if not all) of the inventory in local warehouse when customers are myopic. However, when customers are strategic, the option of carrying all the inventory in central warehouse can be optimal. When customers are strategic, interestingly, the firm can suffer as the local holding cost decreases or a product becomes less perishable.

2 - Lot-sizing with Variable Pricing and Strategic Customers

Philippe Chevalier, UCLouvain, Louvain La Neuve, Belgium, philippe.chevalier@uclouvain.be, Alejandro Lamas

We develop a model and algorithm to jointly optimize supply in a lot-sizing environment and demand management through variable pricing with strategic customers. In particular, we study the optimal scheduling of promotions to maximize profits taking into account revenues but also operations costs.

3 - Breaking Bad: An Analysis of Customer Responses to Failures in Online Grocery Retail

Catarina Pinto, INESC TEC / FEUP, Porto, Portugal, cppinto@fe.up.pt, Pedro Amorim

Despite relying on operational excellence to survive, online grocers often fail by delivering orders that mismatch the ones requested. Few studies have evaluated how customers respond to such events in short-term. By analyzing the changes between subsequent orders, we quantify how customers defect. Our results show a reduction in spending immediately after a failure that increases with the number of failed items. We show the impact of failures depends on the type of failure, customer, and product category. Understanding the magnitude and timing of this reaction leads to personalized inventory management and compensation strategies with important consequences for customer satisfaction.

4 - Pricing and Prioritization in a Duopoly with Self Selecting Customers under Low Utilization

Arvind Sainathan, Nanyang Business School, Singapore, Singapore, asainathan@ntu.edu.sg

We use a three-stage game to investigate the competition between two service providers (SPs) offering service with relatively low utilization to impatient and patient customers. In the first stage, the SPs decide whether to offer single service in which customers are seen on a first-come-first-serve basis, or differentiated service with prioritization. In the second stage, they set their prices. In the third stage, customers self-select and make their purchase decisions. We characterize different equilibria, and show how equilibrium service delivery by the two SPs depends on customer heterogeneity and mix of impatient/patient customers.

5 - Managing Sales of a Complex New Product with Competing Salespeople: Free-riding & Synergy Between Brokers

Vahideh Abedi, California State University Fullerton, Fullerton, CA, United States, vabedi@fullerton.edu, Rahul Bhaskar

Purchase of complex new products (e.g. insurance plans) typically depends on customer word-of-mouth both about the new characteristics of the product and about the quality of service of one or more brokers. We show that this leads to synergy and free-riding effects between brokers that has not been explored in the literature. We model this sales process, and validate it from membership data for an insurance product. We measure the synergy and free-riding effects, and show how the resulting model can facilitate decision making in managing the sales force.

6 - Optimal Rollover Strategies for Stochastic Demand and Production

Justus Arne Schwarz, University of Mannheim, Mannheim, Germany, Oktay Karabag, Baris Tan

A firm that regularly introduces new product generations to the market has to manage the transition phase between generations, i.e., the product rollover. The firm has to decide about the offered quantities, the price of the old generation, and the price of the new product generation. We propose a two-stage optimization problem that explicitly considers stochasticity in demand and production. Optimal decisions are obtained analytically. Managerial insights into the optimal selection of rollover strategies and the sensitivity with respect to demand and production variability are discussed. Moreover, we highlight the differences between the results of a deterministic planning approach.

■ WC57

CC- Yakima 1

Human Trafficking

Sponsored: Public Sector OR

Sponsored Session

Chair: Kezban Yagci Sokat, Northwestern University, Evanston, IL, 60208, United States

1 - Understanding the Impact of Labor Trafficking

Kezban Yagci Sokat, Northwestern University, IEMS, Evanston, IL, 60208, United States, kezban.yagcisokat@u.northwestern.edu, Nezih Altay

Modern day slavery has become an alarming issue in supply chains. We investigate the company policies on labor trafficking and their impact on company performance.

2 - How Supply Chains Break

Shawn Bhimani, Northeastern University, Boston, MA, 37922, United States

We present an econometric analysis of the types and causes of supply chain failure, including a framework to better predict, prevent and understand catastrophic supply chain disruptions. This is critical for continuity of operations in corporate, military, and humanitarian supply chains, as well as for breaking illegal supply chains.

3 - Modeling Operations of Human Trafficking Networks for Effective Interdiction

Kayse Lee Maass, Assistant Professor, Northeastern University, Boston, MA, 02115, United States, k.maass@northeastern.edu, Thomas Sharkey, Lauren Martin, Christina Melander, Kelle Barrick, Tariq Samad

Network interdiction models are a promising method to disrupt human trafficking networks, yet no high-fidelity node-arc network data currently exists. We discuss our ongoing transdisciplinary quantitative analysis of law enforcement case files and stakeholder interviews to identify unique features of human trafficking networks, including their composition, how they adapt to interdictions, and the dependencies between their physical and cyber networks. We highlight our methods for constructing node-arc network representations from qualitative data sources and future research directions for network interdiction models to adapt for applicability to the human trafficking context.

4 - Drivers' Strategic Refusing Behavior in Competition

Xiaojing Feng, Shanghai Jiao Tong University, Shanghai, China, fengxj89@sjtu.edu.cn

Evidence shows drivers' refusing behavior contributes to high incomes, while it harms refused passengers. We propose an analytical model to capture the refusing behavior of different types of drivers, depict the game dynamics between drivers, and explore the effect of the refusing behavior on social welfare under different regulations.

■ WC58

CC- Yakima 2

Big Data V

Contributed Session

Chair: Sareh Nabi, University of Washington, Seattle, WA, 98109, United States

1 - Selecting Interactions in Multiple Regression Models Using Non-Additivity

Sumanta Singha, Indian School of Business, Hyderabad, India, sumanta_singha@isb.edu, Prakash P. Shenoy

In a multiple regression setting, which interaction effects should be included in a model? This is a key research question in statistics. Detecting interaction effects is a challenging due to spurious correlation, multicollinearity, and different meanings of interaction in different fields. The traditional p-value based sequential screening and elimination is computationally intensive and intractable for large number of predictors, besides being less reliable and sometimes misleading. Moreover, this approach often leads to models that are less interpretable. Given these challenges, we propose a novel method of detecting interaction effects using correlation-induced non-additivity.

2 - A Matheuristic to Build Linear Regression Models for Binary Classification

Oliver Strub, University of Bern, Bern, Switzerland, oliver.strub@pqm.unibe.ch

We consider the problem of building linear regression models for the binary classification problem that exhibit various desirable properties such as predictive power, sparsity, limited multicollinearity, robustness, and interpretability. For this problem, we present a matheuristic that employs mixed-integer quadratic programming, lazy constraints, and local search. In a computational experiment, the matheuristic devised, within short computational times, linear regression models exhibiting all desirable properties.

3 - Consumer Loans' First Payment Default Detection: A Predictive Model

Utku Koc, MEF University, Istanbul, Turkey, Turkan Sevgili

A Default Loan (non-performing loan) occurs when there is a failure to meet bank conditions and cannot be repaid in accordance with the terms of the loan which has reached its maturity. In this study, we provide predictive analysis of the consumer behavior concerning a loan's first payment default (FPD) using a real dataset of consumer loans with approximately 600K records from a bank. We use Logistic Regression, Naive Bayes, Support Vector Machine and Random Forest on over-sampled and under-sampled data to build eight different models to predict FPD loans. A two-class Random Forest using oversampling resulted in more than 94% on all performance measures: accuracy, precision, recall, and F1 score.

4 - Distributed Solution of Large-scale Systems of Equations via Accelerated Projection-based Consensus

Navid Azizan, California Institute of Technology, Pasadena, CA, United States, Farshad Lahouti, Salman Avestimehr, Babak Hassibi

Solving a large system of linear equations is a key step at the heart of many algorithms in scientific computing, machine learning, and operations research. When the problem dimension is large, it is necessary to perform the task in a distributed fashion. We consider a setting in which a taskmaster intends to solve a large system of equations with the aide of a number of computing machines. We propose a new algorithm called Accelerated Projection-based Consensus (APC). The convergence rate of the proposed algorithm is shown (both analytically and empirically) to compare favorably with that of alternative distributed methods, such as distributed gradient descent, block Cimmino method, ADMM, etc.

■ WC58a

CC- Chelan 1

1:30-2:15 GameLab

Vendor Tutorial

1 - SodaPop Game: Operations Management Simulation

Felipe Walker, GameLab, Santiago, Chile

The participants will play the SodaPop Game that simulates one year of work in a bottling plant. In the simulation, the participants will be making decisions about the EOQ model.

■ WC59

CC- Chelan 2

Reliability and Maintenance for Complex Engineering Systems

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Wusun Si

Co-Chair: Wujun Si, Wichita State University, Wichita, KS, 67206, United States

1 - Power System Reliability Enhancement with Corrective Topology Control

Xingpeng Li, University of Houston, 4726 Calhoun Road Room N308, Houston, TX, 77204, United States, xli83@central.uh.edu

The electric power system is the world largest human-made "machine" and it is very important to maintain system reliability for supplying continuous quality electricity to consumers. This work investigates (i) the reliability benefits provided by utilizing the flexibility in transmission networks as a corrective control approach; (ii) how those additional reliability benefits can be transferred into economic benefits in the energy management system (EMS). Numerical Simulations demonstrate corrective topology control of the transmission network can achieve substantial reliability benefits, as well as significant cost savings.

2 - Analytics Approach to Support Health-monitoring and Management of Transportation Infrastructure

Pablo L. Durango-Cohen, Associate Professor, Northwestern University, IL, United States, pdc@northwestern.edu

Motivated by recent technological advances, we describe the development and validation of a statistical framework to support health-monitoring and management of transportation infrastructure. The framework consists of formulation of structural time-series models to explain, predict, and control for common-cause variation, and use of multivariate control charts to detect special-cause variation. We present several examples from an in-service bridge to validate the framework.

3 - Forecasting Infrastructure Impacts for Socially-aware Community Resilience with Heterogeneous Data

Bayan Hamdan, University of Illinois at Urbana Champaign, Urbana, IL, United States, bhamdan2@illinois.edu, Pingfeng Wang

The occurrence of disasters remains a highly unpredictable factor in system performance, especially when predicting the resilience of an overall system. The damage of critical infrastructure (CI) needs to be forecasted in order to allocate resources for refurbishment and to increase the resilience by accelerating the recovery process. The use of social media data in conjunction with operational data of the CI will allow for real-time knowledge of damage states and optimized disaster management. Dynamic Bayesian Networks can be utilized to predict the probability of damage in certain areas by taking in sparse time series data and using historic data to predict damage to CI.

4 - Adaptive Preventive Maintenance Integrated with Job Sequence for Smart Manufacturing

Honghan Ye, University of Wisconsin-Madison, Madison, WI, United States

We focus on a joint scheduling problem that considers corrective maintenance and scheduled preventive maintenance (PM) in a generic flow shop. The objective is to find the optimal job sequence and PM schedule such that the total cost is minimized. Most existing studies on PM schedules are based on a fixed PM interval, which is rigid and may lead to poor performances. To address this issue, our novel idea is to dynamically update the PM interval based on real-time machine ages, such that the maintenance activity coordinates with the job scheduling to the maximum extent. To demonstrate the effectiveness of the adaptive strategy, simulations are conducted and a case study on mining operations is carried out.

5 - Bivariate Degradation Modeling with Long Term Memory Effects

Wujun Si, Wichita State University, 11316 E. Pine Meadow Ct, Wichita, KS, 67206, United States, wujun.si@wichita.edu

With advances in sensor technology, oftentimes more than one performance characteristics can be monitored. Conventional degradation modeling with multiple performance characteristics often ignores long term degradation dependencies. In this work, we present a bivariate degradation modeling method with the consideration of long term degradation dependency, based on which reliability analysis is developed. Simulation and case studies are conducted to validate and demonstrate the proposed model.

■ WC60

CC- Chelan 4

Engineering-driven Data Analytics for Complex Systems

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Xiaowei Yue, Virginia Tech, Blacksburg, VA, 24061, United States

1 - Gaussian Process with Input Location Error and Applications to the Composite Parts Assembly Process

Wenjia Wang, SAMSI, Durham, NC, 27713, United States, wenjia.wang234@duke.edu, Xiaowei Yue, Benjamin Haaland, C. F. Jeff Wu

We investigate Gaussian process regression with input location error, where the inputs are corrupted by noise. Here, we consider the best linear unbiased predictor for two cases, according to whether there is noise at the target untried location or not. We show that the mean squared prediction error does not converge to zero in either case. We investigate the use of stochastic Kriging in the prediction of Gaussian processes with input location error. We show that stochastic Kriging is a good approximation when the sample size is large. Several numerical examples are given to illustrate the results, and a case study on the assembly of composite parts is presented.

2 - Active Learning for Gaussian Process Considering Uncertainties with Application to Shape Control of Composite Fuselage

Xiaowei Yue, Virginia Tech, Blacksburg, VA, 24061, United States, xwy@vt.edu, Yuchen Wen, Jeffrey Hunt, Jianjun Shi

In the machine learning domain, active learning is an iterative data selection algorithm for maximizing information acquisition and improving model performance with limited training samples. The existing active learning methods do not incorporate engineering uncertainties (e.g., measurement errors and intrinsic input noise) for Gaussian process. In this paper, we propose two new active learning algorithms for the Gaussian process with uncertainties, which are variance-based weighted active learning algorithm and D-optimal weighted active learning algorithm. Through numerical study, we show that the proposed approach can realize better prediction performance.

3 - Discovering Structure in Longitudinal Data via Coefficient Tree Regression

Ozge Surer, Northwestern University, Evanston, IL, 60201, United States, ozgesurer2019@u.northwestern.edu, Daniel Apley, Edward C. Malthouse

When the data have a spatial and/or temporal component, we often expect that predictor variables that are closer in space and/or time are more likely to be associated with the response in the same way. In such situations, we can exploit those aspects and discover groups of predictors that share the same coefficient according to their spatial and/or temporal proximity. In this study, we propose a new algorithm called coefficient tree regression for longitudinal data to understand the underlying spatial and/or temporal characteristics of the data.

4 - Design and Analysis of Experiments of Tissue-mimicking Meta-structure with Application to Personalized Heart Surgery Planning

Jialei Chen, Georgia Institute of Technology, Atlanta, GA, United States, jialei.chen@gatech.edu, Simon Mak, Roshan J. Vengazhiyil, Chuck Zhang

3D-printed medical phantoms, which use synthetic metamaterials to mimic biological tissue, are becoming increasingly important in urgent surgical applications. However, the mimicking of tissue mechanical properties via 3D-printed metamaterial can be quite difficult and time-consuming. We propose a novel functional-input, functional-output, SpeD emulation model for efficient tissue-mimicking. The proposed emulator model can provide much quicker and more accurate tissue-mimicking performance, compared to existing methods in the medical literature. We then demonstrate the effectiveness of our SpeD emulator in a real-world study on mimicking human aortic tissue.

■ WC61

CC- Chelan 5

Data Fusion for Improved Decision Making

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Mahboubeh Madadi, San Jose State University, Louisiana Tech University, Ruston, LA, 71272, United States

Co-Chair: Anahita Khojandi, University of Tennessee, Knoxville, TN, 37996, United States

1 - A Combined Approach of Change Point Detection and Remaining Useful Life Prediction Based on Double Long Short-term Memory Networks

Zunya Shi, University of Michigan-Dearborn, Dearborn, MI, United States, zunyas@umich.edu, Abdallah A. Chehade

Remaining useful life (RUL) refers to the time left that a system will no longer perform functions. RUL prediction is essential to maintenance scheduling. Due to advanced sensing technologies, large-scale sensor signals can be collected. Among these signals, change points usually exist, indicating the increase of the failure probability. Such information should be considered when predicting the RUL. Therefore, a combined approach of change point detection and RUL prediction using the double long short-term memory (LSTM) networks is proposed in this paper. This new approach is proved to be effective on the turbofan engine degradation simulation dataset carried out by C-MAPSS in the case study.

2 - A Dynamic “Predict and Store” Approach for Renewable Energy

Romesh Saigal, University of Michigan, Ann Arbor, MI, 48103, United States, J. Wang, A. AlSelahi, S. Chung, R. Al Kontar, Eunshin Byon

We explore the use of battery sets to solve the uncertainty from the renewable energy production and the customers’ demand. We propose a stochastic convex program to determine the amount of energy charged into or withdrawn from the battery. The objective is to minimize the expected cost from excess production and shortfall. An iterative approximation algorithm is developed to solve the stochastic convex program. A case study using California Independent System Operator confirms that the resulting battery charge/discharge decision can stabilize the integrated output, neutralizing the volatility of both the renewable energy generation and the demand.

3 - Optimizing Condition-Based Maintenance for Systems with Degrading Sensors

Mahboubeh Madadi, San Jose State University, College of Engineering and Science, PO Box 10348, San Jose, CA, 71272, United States, Anahita Khojandi

We consider a degrading system with silent failures. System failure is costly and it requires an immediate system replacement. The system status can be partially observed using a series of heterogeneous sensors at a given cost. The sensors are not only noisy, but also are prone to degradation themselves, and hence, the sensor noise level is a function of the sensor status. We develop a POMDP model to determine the optimal condition-based maintenance scheme to minimize the total expected discounted cost over an infinite horizon.

4 - Real-Time Sensor Anomaly Detection and Recovery in Connected Automated Vehicle Sensors

Yiyang Wang, University of Michigan, Ann Arbor, MI, United States, Neda Masoud, Anahita Khojandi

In this talk we propose a novel observer-based method that combines signal filtering and anomaly detection together to improve the safety of connected and automated vehicles (CAVs). Specifically, we use extended Kalman filter (EKF) to smooth sensor readings, in which we utilize the leading vehicle’s information to detect sensor anomalies by using trained One Class Support Vector Machine, and a communication time delay factor is considered. Experiments show that compared with the EKF with a traditional fault detector, our method achieves a better anomaly detection performance. They also demonstrate that a larger time delay factor has a negative impact on the overall detection performance.

■ WC62

CC- Tahoma 1

Vaccine Supply Chains

Sponsored: Health Applications

Sponsored Session

Chair: Zahra Azadi, University of Miami Business School, Coral Gables, FL, 33146, United States

1 - Optimization of Pediatric Vaccine Distribution Network Using Chance Constraint Programming

Zahra Azadi, University of Miami Business School, Coral Gables, FL, 33146, United States, zazadi@bus.miami.edu, Sandra D. Eksioglu

We propose a stochastic optimization model that identifies distribution strategies for vaccine vials in developing countries. This is a data driven model which is developed using real life data from Niger. The model captures uncertainties of demand for vaccination via chance constraints. A sample average approximation (SAA) method is used to solve the problem. A comprehensive sensitivity analysis is conducted to evaluate the impact of (i) changing the hierarchy of vaccine distribution network, (ii) changing vaccine vial size from multi-dose to single-dose, and (iii) replacing regular vaccines with dual chamber and thermostable on immunization coverage.

2 - Pricing Strategies in the United States Pediatric Vaccine Market

Banafsheh Behzad, Assistant Professor, California State University, Long Beach, 1250 Bellflower Blvd, MS 8506, Long Beach, CA, 91101, United States, banafsheh.behzad@csulb.edu, Kayla Cummings, Susan E. Martonosi

Pricing strategies in the United States pediatric vaccines market are studied using a game theoretic approach along with an optimization model. The game analyzes the competition between asymmetric, capacity-constrained manufacturers (i.e., manufacturers with unequal and limited production capacities) producing differentiated products in a market with linear demand. The optimization model from the CDC’s perspective minimizes negotiated government costs while ensuring adequate national vaccination levels, linking dynamics in public and private sectors, and incorporating competitive manufacturer behavior.

3 - Modeling Outreach for Who-EPI Vaccine Distribution

Yuwen Yang, University of Pittsburgh, Pittsburgh, PA, 15213, United States, Jayant Rajgopal

In many low and middle-income countries with geographically dispersed or nomadic populations, last-mile vaccine delivery can be extremely complex. Without convenient access to clinics and hospitals, an approach known as outreach is typically utilized. A set of remote population centers is chosen, and over an appropriate time horizon, clinical teams are sent from a depot to set up mobile clinics at these locations to vaccinate people in the immediate surrounding area. We present and discuss a model that is a combination of a set covering problem to choose mobile clinic locations and assigning population centers to them, and a vehicle routing problem to select routes to visit these mobile clinics.

4 - An Or-based Hypothetically Coordinated Vaccine Market

Ruben Proano, Rochester Institute of Technology, Gleason College of Engineering, 81 Lomb Memorial Drive, Rochester, NY, 14623, United States, rpmeie@rit.edu

This study presents a hypothetically coordinated vaccine market where coordinating entities rely on an optimization-based process to make procurement decisions on behalf of buyers grouped in market segments to ensure affordability and profitability. We illustrate the effect of several experimental factors on affordability. Results show that increasing the number of market segments per coordinating entity increases welfare and that having entities with few markets to support favors low-income affordability. This study shows the implications of this study on optimal market segmentations for low-income and middle-income countries.

■ WC63

CC- Tahoma 2

Cancer Treatment Plan Optimization

Sponsored: Health Applications

Sponsored Session

Chair: Ehsan Salari, Wichita State University, Wichita State University, Wichita, KS, 67260, United States

1 - Integrating DVH Constraints and Beam Angle Optimization into Automated Radiotherapy Treatment Planning

Masoud Zarepisheh, Memorial Sloan Kettering, New York, NY, 10017, United States, Linda Hong, Sovanlal Mukherjee, Vicki Taasti, Joseph Deasy

This study automates IMRT treatment planning by formulating that as a hierarchical constrained optimization problem (also known as prioritized optimization). We introduce a 2-phase technique to handle the DVH constraints efficiently, where the first phase solves an optimization problem with a convex relaxation version of the DVH constraints. The second phase then imposes maximum dose constraints on the low dose voxels identified in the first phase which guarantees the DVH constraints satisfaction. We also show how the Bayesian Optimization technique can be used to optimize the beam angles.

2 - Towards Optimal Stopping of Radiation Therapy Through Dynamic Information Flow

Ali Ajdari, Research fellow, Harvard Medical School & Massachusetts General Hospital, Boston, MA, 02115, United States, aajdari@mgh.harvard.edu, Thomas Bortfeld

In the era of precision medicine and personalized radiation therapy, there is an ever-growing need to tailor the treatment plans to individual patient's radiosensitivities. Optimal Stopping in Radiotherapy (OSRT) is a novel approach in which treatment plans for each individual patient get adapted midway through the treatment course, using information provided by predictive biomarkers. Using dynamic programming and predictive modeling, we investigate the effect of dynamic information flow on the performance of OSRT, and show how the frequency, quality, and the timing of information acquisition can affect the therapeutic window, and the subsequent adapted plans.

3 - A Control-theoretic Framework for Real-time Organ Motion Management in Radiation Therapy

Seyed Ali Mirzapour, Wichita State University, Wichita, KS, 67220, United States, mirzapour.ie@gmail.com, Thomas Mazur, Gregory Sharp, Ehsan Salari

Internal organ motion during irradiation is a major concern in the treatment of thorax and abdominal cancers. A recent development is the advent of radiotherapy devices with an on-board MRI scanner, capable of providing a real-time view of the patient anatomy with a high temporal resolution during radiation delivery. This research aims at developing a control-theoretic framework that uses real-time MRI information to monitor and correct the radiation delivery progress in real time. This is achieved by continuously estimating the cumulative deposited dose during irradiation, which serves as a feedback signal for a stochastic control problem to dynamically adjust the treatment plan if warranted.

4 - A Risk-based Modeling Approach for Radiation Therapy Treatment Planning under Tumor Shrinkage Uncertainty

Saba Ebrahimi, University of Houston, Houston, TX, 77054, United States, sebrahimi@uh.edu, Gino J. Lim, Wenhua Cao, Laleh Kardar

We proposed a risk-based robust approach using CVaR representation of dose-volume constraints to mitigate the risk and achieve risk-averse. Our results showed that the proposed approach outperformed conventional robust optimization in terms of dose variability and control on the worst-case scenarios while delivering the prescribed dose to the tumor target and sparing organs at risk.

5 - Multi-modality Radiotherapy Optimization

Roman Levin, University of Washington, Seattle, WA, United States, rilevin@uw.edu, Aleksandr Y. Aravkin, Minsun Kim

Radiotherapy is used to treat cancer patients using ionizing radiation to damage the tumor. X-rays are the most widely used radiation modality, however, there is a growing interest in using other radiation types, e.g.protons, due to their unique dosimetric and biological properties. Current attempts to determine an optimal radiation modality or a combination of modalities are mostly empirical. We propose a novel mathematical framework to maximize the damage to the tumor while sparing normal tissue in the multi-modality setup. We develop algorithms to efficiently solve the underlying non-convex optimization problem and find the optimal radiation dose distributions with the number of fractions.

■ WC65

CC- Tahoma 4

Illicit Supply Chain in Healthcare

Sponsored: Health Applications

Sponsored Session

Chair: Naoru Koizumi, George Mason University, Arlington, VA, 22201, United States

Co-Chair: Monica Gentili, University of Louisville, Louisville, KY, 40292, United States

1 - Identification of Functional Entities Engaged in Sale and Distribution of Illicit Commodities

Saurav Kumar Dubey, PhD, South Dakota School of Mines and Technology, Rapid City, SD, United States

A functional entity is defined as an organization or a group of people performing a critical task that serve as a vital link in the sustainment and resiliency of an illicit supply chain (ISC). The focus of this study will be to identify such entities and propose an allocation model that would assist law enforcement agencies with deployment of constrained fiscal resources to maximize impact of interdiction efforts. The proposed model will assign relative numerical importance or weights to ISC members comprising of Manufacturer, Wholesaler, Distributor and Retailer. To validate the proposed model, flow of illicit commodities in the healthcare industry will be the subject of investigation.

2 - A Preliminary Analysis of Illicit Kidney Sales in Developing Countries

Monica Gentili, PhD, University of Louisville, Louisville, KY, United States, monica.gentili@louisville.edu

The illicit organ sales network system often consists of multiple players, typically involving organ (mostly kidney) sellers, buyers, transplant service providers, brokers and financial institutions that pass money from organ buyers to other actors. Inter-actor social networks are inherent in organ trafficking. However, no rigorous analysis has been applied thus far to investigate the system. We present some preliminary results in this context related to the analysis of illicit organ sales in Bangladesh.

3 - A General and Adaptive Approach to Studying Falsified Pharmaceutical Supply Chains

Eugene Wickett, Northwestern University, Evanston, IL, United States, eugenewickett2022@u.northwestern.edu, Reut Noham, Karen Smilowitz

Falsified and substandard drugs constitute at least 10% of supplies in low- and middle-income countries, driving high levels of mortality and morbidity from otherwise preventable causes. We develop a general and adaptive approach to understand the conditions under which low-cost detection devices can be used to detect falsified and substandard pharmaceuticals. The flexible structure described allows stakeholders to ascertain the limitations and feasibility of sample testing policy for a particular drug before committing valuable resources.

4 - Analysis of Illicit Kidney Trade Networks

Naoru Koizumi, George Mason University, School of Public Policy, 3351 North Fairfax Drive, Arlington, VA, 22201, United States, nkoizumi@gmu.edu, Abu Bakar Siddique, Amit Patel, Brian Wilson

The transnational transplant tourism has been on the rise. Several regional hubs are emerging in recent years. The kidney trade networks tend to be complex involving transnational actors of buyers, sellers, brokers and surgeons. However, this field lacks scientific tools and empirical data that can help understand the extent of the problem. We developed an algorithm to gather data from newspaper articles about the regional hubs of kidney trade and then identified the factors determining the country networks.

■ WC66

CC- Tahoma 5

Reliability II

Contributed Session

Chair: Carlos Solorio, IENAC/CETYS, Calexico, CA, 92232-4184, United States

1 - Reliability Analysis and Modeling of Concrete Bridge Decks

David W. Coit, Rutgers University, Piscataway, NJ, United States, coit@soe.rutgers.edu, Nooshin Yousefi, Hani Nassif, Jian Zhou

Degradation modeling is an important issues for reliability analysis and failure prediction. We develop a stochastic degradation model for corrosion deterioration of a concrete bridge deck with different types of steel reinforcement. Various parameters such as crack width, crack depth and Sodim chloride concentrations as the environment stress are the most important factors to be considered for the stochastic degradation modeling. For different types of steel reinforcement and Sodium chloride concentrations, the time for corrosion initiation and propagation is different. The proposed degradation model is used to analyze the reliability and predict the failure time of concrete bridge deck.

2 - Covariate Selection Considering Measurement Error with Application in Accelerated Life

Samira Karimi, University of Arkansas, Fayetteville, AR, United States, sakarimi@uark.edu, Haitao Liao

Unimportant covariates and measurement error in important covariates are common issues faced by practitioners. The errors and irrelevant information may decrease the precision and accuracy of the estimates of interest while significantly wasting computational efforts. Despite the extensive studies on Accelerated Life Testing (ALT), the presence of measurement errors in covariates of ALT data has not received much attention. Using Measurement Error Boosting algorithm, in this work, a number of widely used distributions in reliability, including Weibull and Lognormal, are studied for covariate selection and measurement error elimination.

3 - Statistical Modeling of Multivariate Destructive Degradation Tests with Blocking

Qiuzhuang Sun, National University of Singapore, Singapore, Singapore, qiuzhuang.sun@u.nus.edu, Zhi-Sheng Ye, Yili Hong

In degradation tests, test units are usually divided into groups. Due to block effects, degradation differs among blocks but is more homogeneous within a block. Motivated by an application of emerging contaminants, this study proposes a multivariate statistical model to account for the two-layer block effects in destructive degradation tests. Through a case study, we show the existence of the block effects from a proposed test. Decision-makers can then readily make risk assessment of each contaminant and determine the minimal water treatment time for their removal by using the proposed model.

4 - Planning Accelerated Degradation Tests with Two Stress Variables

Guanqi Fang, Arizona State University, Tempe, AZ, United States, gfang5@asu.edu, Rong Pan, John Stufken

In this talk, a methodology to provide optimal design for accelerated degradation tests with two stress variables will be given. Decisions including selecting the stress levels with the corresponding test unit allocation are to be made. It will be demonstrated using a real optical media industrial dataset.

5 - Data Intensive Industrial Asset Management for Distributed Energy Resources

Hamid Seifoddini, University of Wisconsin-Milwaukee, Milwaukee, WI, United States, Farhad Balali, Adel Nasiri

The reliability of the electrical networks significantly impacts customer as well as energy providers' bottom line. Prognostics and Health Management (PHM) becoming a critical factor in the efficiency of the energy sector. Degradation based analysis is one of the valuable approaches to condition-based algorithms in order to obtain reliability information. The main purpose of the degradation-based models is to predict the future condition of the asset and perform the maintenance in an optimized time window. The methodologies of the General Path (GP) and Autoregressive(AR) models as robust degradation models would be discussed in detail.

6 - Multi-state System Reliability Subject to Multiple Failure Modes.

Carlos Solorio, CETYS University, Mexicali, Mexico, carlos.solorio@cetys.mx

This research studies the reliability of complex multi-state engineering systems that suffer multiple failures caused by common degradation of physical systems and catastrophic failures caused by sudden shocks. A reliability model is presented based on multi-state systems with multi-state components, the reliability of the system is computed based on the state of the components. New performance measures for the system are presented considering component degradation at any level and the disutility function is incorporated. The proposed reliability model can be used directly or customized to many complex systems that experience degradation due to wearing and sudden shocks.

■ WC67

S- Virginia

Health Care, Processes

Contributed Session

Chair: Kleber Esposto, Universidade de Sao Paulo, R Douvidor Cunha 116, Sao Carlos, 13569580, Brazil

1 - Patient Flow Improvement at the Emergency Department of a Local Hospital through Simulation Modeling

Hongyi Chen, University of Minnesota Duluth, Duluth, MN, United States, honchen@d.umn.edu

A two-stage simulation model was developed to help improve the patient flow in the ED of a local hospital in Duluth, Minnesota. In the first stage, a general model was built focusing on verifying bottlenecks perceived by the ED physicians and staffs. In the second stage, a detailed model was built to further identify bottlenecks and test impacts of process changes proposed by the vertical triage team at the hospital. Seeing great improvement to the patients' door-to-bed time as forecasted by the simulation model, a new process called JET was implemented in the ED. Performance metrics acquired after the implementation of JET validated the forecasts from the simulation model.

2 - Impact of Patient Complexity on Patient Flow in EDs

Seung Yup Lee, University of Calgary, Calgary, AB, Canada, seungyup.lee@haskayne.ucalgary.edu, Marco Bijvank

ED patient condition entails two notions, urgency and complexity. While the notion of urgency is well established, referring to the clinical priority of a patient, complexity is an immature concept that could bring significant operational implications on ED care delivery. We characterize patient complexity levels by proposing a measurement method designed by a system-wide study on operational/clinical data from four different EDs and report operational insights. The results provide a novel view point on decision makings (e.g., patient selection) in managing clinical needs of ED patients.

3 - The Role of Team Familiarity to Improve Surgical Team Performance in Operating Room

Jaeyoung Kim, Clemson University, Clemson, SC, United States, jaeyouk@clemson.edu, Lawrence Fredendall, Robert Allen, Marissa L. Shuffler, Dana Verhoeven

This study examines the impact of team familiarity (team experience working together in the past) on surgical team performance using a perioperative dataset from a major local hospital system. First, the existing team familiarity measurements are reviewed, and appropriate measures of team familiarity of surgical teams in operating room are selected. Next, the case-level perioperative data such as scheduled procedure durations and actual procedure durations are analyzed to identify how team familiarity affects surgical team performance.

4 - Blockchain in Healthcare: How Smart Contracts Can Change Prescriptions

Leston Alvarez, Researcher, University of Lethbrisge, AB, Canada, Lethbridge, AB, Canada, Afrooz Moatari-Kazerouni

Healthcare sector is lagging behind when it comes to adopting with technology advancements. Blockchain being one of the current leading technologies, within this research, the blockchain technology is examined in the context of smart contracts for replacing paper prescriptions. The idea of utilizing blockchain for allowing doctors, clinics and patients to create smart contracts for simpler transactions is explored. The current method of organizing data is inefficient to what could be potentially resolved by implementation of blockchain technology. The solution of blockchain could prevent medical mistakes and misplacements of healthcare data within the current system.

5 - Utilization of System Modelling Techniques in Lean Healthcare Applications

Raja Jayaraman, Khalifa University of Science & Technology, Abu Dhabi, United Arab Emirates, raja.jayaraman@ku.ac.ae, Mecit Can Emre Simsekler, Maitha AlKaabi, Kudret Demirli, Emin Murat Tuzcu

There is an increasing awareness on the utilization of lean in healthcare to implement waste-free operational processes. Another potential approach that can be merged with lean is systems approaches, such as System Modelling Techniques (SMTs), to help identify comprehensive list of wastes in a systematic way. To investigate the potential linkage between lean and SMTs, this paper reviews the literature in the field and provides a conceptual framework between these two complementary approaches.

6 - Literature Review of Critical Success Factors for Lean Healthcare Sustainability

Kleber F. Esposto, USP - Universidade de São Paulo, Sao Carlos, Brazil, kleberesposto@usp.br, Debora Helal, Rapinder Sawhney

According to literature review conducted for this study, little has been addressed about sustainability of lean healthcare improvements. In this way, this paper aims to review the critical success factors for lean sustainability in healthcare settings reported in literature. To accomplish that, a compilation of critical success factors of lean and lean healthcare was carried out, where 47 articles with 231 critical success factors were analyzed and grouped into 17.

■ WC68

S- University

Green Manufacturing and Operations/ Finance Interface

Contributed Session

Chair: Tiffany Zhu, University of Pittsburgh, Pittsburgh, PA, 15232, United States

1 - Quality and Productivity Trade-off in Powder-bed Additive Manufacturing

Huseyin Kose, University of Tennessee, Knoxville, TN, United States, Mingzhou Jin

Quality and productivity are the two key concerns in Powder-bed AM processes. Because of keyhole and porosity formation occurring in the object's structure, quality is considered a difficult factor to manage. Focusing only improving quality could result in high building cost. In this study, outcomes obtained from previous studies were combined in a systematic way to create an empirical model to optimize major process parameters to make a trade-off between quality and productivity. The lowest building cost obtained in case study among other studies selected from literature. Results showed how empirical model is effective on minimizing building cost by maximizing productivity at any quality level.

2 - Improving Product Service Systems through Modular Architecture

Johnson Adebayo Fadeyi, University at Buffalo, Buffalo, NY, United States, jfadeyi@buffalo.edu, Leslie Monplaisir

Manufacturers are moving from product selling towards product service system (PSS). It is argued that PSS enhances environmental sustainability because fewer products are required for extensive usage, thereby reducing resources consumption. However, products with high environmental impact at the "use phase" will not realize this objective. Therefore, it is essential to consider the eco-indices of the products' parts during product development. This study determines the eco indicators of module variants and identifies the product architecture that enhances environmental sustainability. The study provides product configuration decision guide to the original equipment manufacturer.

3 - Market Reactions to Changing Fuel Efficiency Standards

Caroline Swift, PhD Student, The Pennsylvania State University, University Park, PA, United States, cas669@psu.edu, V. Daniel R. Guide, Suresh Muthulingam

We use publicly available financial information to understand stock market reactions to changes in automobile fuel efficiency standards. We analyze how market valuations differ across affected industries and manufacturers' product line composition.

4 - Milestone-Based Supply Chain Finance

Yuxuan Zhang, PhD, Tsinghua University, Beijing, China, Hau L. Lee, Christopher S. Tang, S. Alex Yang

This study examines the value of information updating in a milestone-based supply chain finance scheme. We find that the value of information increases as the trade process becomes more reliable, and as the value of the traded goods increases significantly as the order successfully passes the milestone. The value of information becomes also higher as the bank's cost of equity increases.

5 - A Real Option Theory of Financial Hedging and Operational Flexibility

Chenchen Di, UIUC, Champaign, IL, United States, cdi2@illinois.edu, Arkadiy Sakhartov

This paper investigates the relationship between financial hedging and operational flexibility. Using a formal model, we show that whether financial hedging and operational flexibility are substitutes or complements depends on the inducements including return volatility, redeployment cost and risk aversion. The model provides an integrated framework and rationale to reconcile the tension about the relationship between financial hedging and operational flexibility.

6 - The Impact of Board Diversity on Corporate Social Responsibility and Operating Efficiency

Tiffany Zhu, University of Pittsburgh, Pittsburgh, PA, United States, zhz90@pitt.edu

More and more studies have shown that board diversity affects the firm's performance. Nowadays, shareholders pay more attention to board diversity. This study empirically examines how the diversity of a firm's board members affect its Corporate Social Responsibility performance and operating efficiency. We use cross-country firm-level data and explore board diversity on the dimensions of gender, race, age, tenure, power, expertise, insider-outsider ratio, education, experience, network connections among board members, and nationality.

■ WC69

S- Seneca

Supply Chain Management and Remanufacturing

Contributed Session

Chair: Morteza Alizadeh, Mississippi State University, Starkville, MS, 39759, United States

1 - Product Recovery Decision-making in the Context of Internet of Things: A Review and Generic Roadmap

Xianghui (Richard) Peng, Assistant Professor, Penn State Erie The Behrend College, Erie, PA, United States, xzp17@psu.edu, Kai Meng, Ying Cao, Victor R. Prybutok

We provide a state of the art review on End-of-Life (EOL) product recovery decision-making in the context of Internet of Things. We contextualize an implementation framework to enable sustainable EOL product management based on enriched information. We propose a generic roadmap for model and methodology selection to assist practitioners.

2 - Research on Recovery Model of Closed Loop Supply Chain for Electronic Products in Online to Offline Model

Dong Yang, Xidian University, Xi'an, Shaanxi, China, xjtuyd@163.com

Compared with the traditional closed loop supply chain recycling model, the selection strategy of the manufacturing enterprises and consumers has changed in the O2O model. The steady state equilibrium values of two models are given by constructing the closed loop supply chain recovery model of consumer electronics products under the dominant model of manufacturing enterprises or O2O platform. The results show that the government subsidies, the recycling price, quantity and instantaneous profits gradually increased over time. Recovery costs, except the recovery prices, will affect the recycling model choice of manufacturing enterprises.

3 - Robust Design of Bioenergy Supply Chain Network under Multidimensional Uncertain Environment

Qiaofeng Li, Tsinghua University, Beijing, China, lqf16@mails.tsinghua.edu.cn, Jingran Liang, Zhihai Zhang

Bioenergy is one of the rapidly growing renewable energy worldwide. The investment in bioenergy is expected to increase in the future. This article investigates strategic recycling network planning for bioenergy supply chain under multiple uncertainties to minimize the total cost. Extensive numerical experiments are conducted. And, an industrial case study is considered to illustrate that the proposed approach is efficient.

4 - Sustainable Supply Chain Performance: A Relational View

Gopal Kumar, Assistant Professor, IIM Raipur, Raipur, India, gopalkumar@iimraipur.ac.in, Purushotam L. Meena, Rita Maria Di Francesco

By focusing on partnering capabilities, this study explores the need to build capabilities to cope with the fast-changing business environment to achieve supply chain sustainability. This study underlines collaboration, capabilities, and commitment in developing triple-bottom line (TBL) performance. Empirical analysis shows that collaboration, culture, and commitment play a crucial role in building capabilities, which in turn achieve TBL performance. Culture- and commitment-related traits are strong for downstream collaborating firms.

5 - Marine Debris Collection Ship Routing Problem

Morteza Alizadeh, Graduate Research Assistant, Mississippi State University, Starkville, MS, United States, ma1845@msstate.edu, Gang Duan, Farjana Nur, Mohammad Marufuzzaman, Junfeng Ma

We propose an overall framework to collect debris throughout ocean in three phases. First phase determines initial locations of debris using satellite imagery with remote sensing. Wind and ocean currents drift debris to other locations. Second phase uses GNOME to predict momentary trajectory of debris. Third phase develops a ship routing optimization model to collect and remove debris from ocean. Due to provisional debris locations, hard time window is set debris locations that restricts ships to reach debris locations within a certain time range. Carbon cap policy is applied to minimize carbon emissions of ships. Results reveal capability of proposed framework in handling marine debris problem.

■ WC70

S- Jefferson A

Cost Analysis and Inventory Management

Contributed Session

Chair: Xiaotong Liu, Tsinghua University, Nanshan Distrct, Shenzhen, 518055, China

1 - Selecting Between Batch and Batch Synchronized Zone Picking Considering Learning Effects

Jun Zhang, Central China Normal University, Wuhan, China, zhangj@mail.ccnu.edu.cn

We compare batch picking and batch-synchronized zone picking strategies. To better predict picking performance and more accurately evaluate the picking efficiency of the two strategies, pickers' learning effects are considered. We formulate the batch generation and batch assignment models with learning effects to minimize the total service time. The improved batching methods are proposed to solve the batch models, and a series of experiments are addressed to compare the picking efficiency. The results show that when pickers have good learning abilities, although batch picking performs better at beginning, batch-synchronized zone picking can surpass it after several days' learning.

2 - A Cost and Performance Optimisation Model Proposal for Integrating Predictive and Scheduled Maintenance in Aviation

Danilo G. Pinto, Maj Engr. MSc, ITA (Technological Institute of Aeronautics), Sao Jose dos Campos, Brazil, danilodf@ita.br, Fernando T. Abrahão

The full realisation of the potential benefits offered by IVHM (Integrated Vehicle Health Management) technologies requires yet the harmonisation of predictive and preventive maintenance tasks in a single plan. In this sense, an unprecedented optimisation model is proposed for minimising cost and downtime while also taking into consideration the uncertainties involved in Remaining Useful Life (RUL) forecasts. The method encompasses all relevant parameters in order to combine the two types of maintenance in a unified framework that is intended to support decision over which activities should be performed according to prognostics and which should be left in preventive maintenance packages.

3 - Total Cost of Ownership Analysis for Power Battery Consumer under Charging Modes

Chunyan Duan, Tongji University, Shanghai, China, duanchunyan77@163.com, Xiaoyue You, Qiang Chen, Mengmeng Shan

To analyze the total cost of ownership for power battery consumer, charging modes must be considered. We conducted a sensitivity analysis of total cost of ownership for power battery consumer under the fast charging and slow charging modes by taking the power battery of a private consumer's electric vehicle as an example. These results provide positive supports consumers' decisions, manufacturers' decisions and so on.

4 - Cycle Costs in Continuous Review Inventory Control

Dincer Konur, Texas State University, San Marcos, TX, United States, d_k141@txstate.edu, Gonca Yildirim

In this study, we consider cycle costs in the analysis of continuous review inventory control models. In particular, we first investigate a (Q,R) model with the objective of minimizing the maximum cycle cost possible. Then, a bi-objective model is presented to minimize both the expected cost per unit time and the maximum cycle cost possible. An extensive set of numerical analyses demonstrate the benefits of the proposed methods.

5 - Deployment Model with Network Inventory

Nayeon Kim, PhD Candidate, Georgia Institute of Technology, Atlanta, GA, United States, nkim97@gatech.edu, Benoit Montreuil, Walid Klibi

We model dynamic inventory deployment over an open distribution network in North America under service level requirements with network inventory. The model allows multi sourcing, flexible order allocation and lateral transshipment. The proposed model is evaluated by being compared to alternative deployment and inventory control models and distribution networks.

6 - Analysis of Logistics Service Supply Chain for the One Belt and One Road Initiative of China

Xiaotong LIU, Tsinghua University, Shenzhen, China, tju_lxt@163.com

This paper explored the supply chain coordination issues arising from the One Belt and One Road initiative (OBOR), and investigated the impacts of the cost sharing contract on the key decisions for logistics service supply chain with mass customization. As a result, several key managerial insights were discovered in our modeling study. More importantly, the impacts of cost-sharing on the key decisions of each player was analyzed in details, and the interaction mechanism of mass customization was also estimated. From our perspective, it will be indeed beneficial to improving logistics service in the OBOR region.

■ WC71

S- Jefferson B

Information Systems IV

Contributed Session

Chair: Mahdi Boucetta, Mississippi State University

1 - An Analysis of Consumers' Attitudes Toward Smart Home Internet of Things Privacy Risks

Daeeun Choi, Virginia Tech., Blacksburg, VA, United States, dechoi@vt.edu, Paul Benjamin Lowry

This study analyzes consumers' attitudes toward privacy, of those who might potentially purchase smart home Internet-of-things (IoT) products. We conducted random scraping and cleaning of IoT privacy-related data via Google search, and analyze them with sentiment analysis and machine learning methods. To automatically collect and analyze the data, we used Python with textblob and the natural language processing toolkit. The results suggest that consumers tend to ignore privacy risks toward IoT technology. This outcome will be tested via a survey research to measure the consumers' attitude toward privacy of IoT.

2 - Wearables and Health Behavior Change: A Qualitative Investigation of Barriers

Madhav Sharma, Spears School of Business, Stillwater, OK, United States, madhav.sharma@okstate.edu

Wearable technologies are becoming increasingly pervasive and advanced. With sustained market share and rapid advancements in design, wearables have the potential to be the information system that can bring about a significant change in user's lifestyle and healthcare behaviors. The goal of this research is to create a deeper understanding of the factors inhibiting the relationship between use of wearables and health behavior change using an interpretivist approach. In this paper, we qualitatively identify barriers and attempts to overcome the said barriers via interviewing participants with varying degree of context knowledge.

3 - The Role of Media Richness, Victim-offender Relationship, and Demographic Characteristics in Cyberbullying: A Country Wide Investigation

Zhuojian Jia, Nanyang Technological University, Singapore, Singapore, Mariana G. Andrade-Rojas, Lai Lai Tung

We examine the relationship of media richness and victim-offender relationship with intensity of victim's responses in cyberbullying. We analyze a country-wide survey of more than 13,000 responses. Using multinomial logistic models, we find that victim responses become more active with greater media richness or offender intimacy. Factors including gender, age, and cyberbullying frequency show significant moderating effects. This project is funded and supported by Nanyang Technological University under the Undergraduate Research Experience on CAmpus (URECA) programme.

4 - Interpersonal Social Media Uses: Within-person and Between-person Relationships with Citizenship Behavior and Job and Life Satisfaction

Kriti Chauhan, University of Louisiana - Monroe, Monroe, LA, United States, chauhan@ulm.edu, Sridhar P. Nerur, Marcus Butts

Social media use during work has become commonplace. This study explores within-person and between-person relationships among different types of social media uses with employee citizenship behavior and job and life satisfaction. The three types of interpersonal social media use examined in this study are private - interacting with friends and family, professional - interacting with work colleagues, and public - interacting with others online. Nature and strength of relationships differs by type of social media use and the level of analysis. Multilevel modeling is carried out on experience sampling data from 91 people over three weeks.

5 - An Examination of the Impact of Health Information Technology on Knowledge Transfer Across Hospitals

Onyi Nwafor, University of North Carolina at Greensboro, Greensboro, NC, United States, Xiao Ma, Norman Johnson

A widely-accepted tenet of the organizational learning literature is that the technological ties between organizations can facilitate knowledge transfer between them. However, there is little empirical evidence to support this notion. Moreover the literature provides little insight on the mechanisms by which technological ties between organizations can facilitate knowledge transfer. Using a sample of hospitals organized in healthcare systems as a point of reference, we examine the impact of health information technology (HIT) ties on knowledge transfer and consider the relative impact of various attributes of the HIT ties between the hospitals that may explain measured knowledge transfer.

6 - Requirement Engineering: Elicitation and Validation for Small and Medium-sized Enterprises

Mahdi Boucetta, Mississippi State University, Starkville, MS, United States, mb3736@msstate.edu, Raed Jaradat

The uncertainty of customers' demands require small and medium-sized enterprises (SMEs) to be more responsive and resilient and also achieve better prosperity and recognition. This research addresses the problem of introducing systems with integrated management applications of SME-type enterprises. In particular, we consider the main phase of this project as the Requirements Engineering phase.

■ WC72

S- Columbia

Joint Session ISS/Practice Curated: Information Security

Sponsored: Information Systems

Sponsored Session

Chair: Antino Kim, Indiana University, Bloomington, IN, 47405, United States

1 - Blockchain Platform Network Externalities

Hemang Subramanian, Asst. Professor, Florida International University, Miami, FL, 33193, United States, hsubrama@fiu.edu

Blockchain technologies allow the sharing of revenues from traditional exchange-based markets to network participants. In this paper, I model externality effects among different sides of a blockchain platform extending Parker and Van Alstyne(2006). Next, I empirically analyze the causal direction of flow of value from exchange markets to participants on a blockchain based content platform using time series regressions and Granger Causality analysis. Then, I analyze, the effects of user heterogeneity and content heterogeneity on the externality effects and value flows in this market. Results indicate a value transfer between token markets and content creators based on the type of content.

2 - Economics of Ransomware Attacks

Duy Duc Dao, University of Calgary, Calgary, AB, 95111, Canada, Terrence August, Marius Florin Niculescu

In this paper, we examine how ransomware impacts software vendors and consumer behavior. When victims face an option to mitigate losses via a ransom payment, both the equilibrium market size and the vendor's profit under optimal pricing can actually increase in the ransom demand as well as the risk of residual losses following a ransom payment (which reflect the trustworthiness of the ransomware operator). We also show that the expected total ransom paid is non-monotone in the risk of success of the attack, increasing when the risk is moderate in spite of a decreasing ransom-paying population.

3 - Optimal Policies for Information Sharing in Information System Security

Yueran Zhuo, Harvard Medical School, Boston, MA, United States, Yzhuo1@mgh.harvard.edu and University of Massachusetts-Amherst, Amherst, MA, United States, yzhuo1@mgh.harvard.edu, Senay Solak

Information sharing has become a significant part of information security, as many firms have come to realize that it is difficult to defend against the sophisticated information security attacks with the limited resources of one single firm. The sharing of information security related knowledge and experience helps firms better prepare for upcoming information security challenges. We show our analysis under symmetric and asymmetric information sharing environment respectively. The results provide insights on optimal information sharing level decisions for different sized firms over different operational environments. The value of information sharing is also examined.

4 - Data Breaches and Firm IT Investment

Kathy Cao, Iowa State University, Ames, IA, United States

This paper explores how a firm responses to a security breach happened regarding its information technology (IT) investment. We explore two aspects of information technology, total IT budget, and number of IT employees. We analyze the IT investment change at both the firm- and establishment-level with a panel data of over 3,000 firms and 350,000+ sites from year 2010 to 2016. The analysis shows overall a breached firm invests more in IT after the breach took place. However, the firm does not necessarily invest more in the establishment where the breach happened, unless the establishment is a regional headquarter, close to the headquarter, or in the primary industry of the firm.

5 - Source Ratings in the Fight against Disinformation on Social Media

Patricia Moravec, University of Texas at Austin, Kelly School of Business, Austin, TX, United States, Antino Kim, Alan R. Dennis

The rise of fake news has become a major concern for social media platforms and their users. One possible solution is to attach a rating of the source that produced the article to every article when it is first published. We conducted online experiments to investigate the effects of source ratings on user's belief in news articles on social media.

■ WC73

S- Boren

Student Successes - Practical Magic from our EMBA/MBA/DMBA/MSDA Programs

Emerging Topic: INFORMS Section on Practice

Emerging Topic Session

Chair: Peter C Bell, Ivey Business School at Western University, Canada, London, ON, N6G 0N1, Canada

1 - EMBA Student Projects as Examples of Applied Analytics

Peter C. Bell, Ivey Business School at Western University, Canada, Ivey School of Business at Western Universty, 1255 Western Road, London, ON, N6G 0N1, Canada, pbell@ivey.ca

Join us as our panelists present practical magic: successful student presentations, learning outcomes, projects, and more from Executive MBA, MBA, and Data Analytics programs. Many of these programs are geared to teach direct job skills in a very short period of time. Panelists include the university perspective with contributions from Western University in Canada and UC Irvine, and the industry perspective from Analytics2Go. Do you want to know what's brewing in terms of skill set development? Come see this panel and find out.

Panelists

- Peter C. Bell, Ivey Business School at Western University, Canada, Ivey School of Business at Western Universty, London, ON, N6G 0N1, Canada
- Kenneth E. Murphy, University of California Irvine, Irvine, CA, 92866-1005, United States, murphyke@uci.edu
- Aaron Burciaga, Analytics2Go, Tysons, VA, 22102, United States
- Haluk Demirkan, University of Washington-Tacoma, Bellevue, WA, 98005, United States

■ WC75

S- Metropolitan Ballroom A

Flash Session VIII

Flash Session

Chair: Jyotishka Ray, Assistant Professor, California State University, East Bay

1 - Recommendation in a High Online Traffic under Constrained Inventory

Jyotishka Ray, Assistant Professor, California State University - East Bay, Hayward, CA, United States, jyotishka.ray@csueastbay.edu

Holiday buying seasons like Cyber Monday, Black Friday and others are characterized by high online demand with a high stockout risk. To mitigate the adverse effect of stockout the e-retailers, in general, had to forego some of the profit margin to provide stockout compensation in terms of price discount, free shipping and gift cards for the backordered item. This study designs a RS from the retailer's perspective who maximizes her expected profit by recommending protable yet popular items while incurring stockout compensation cost in case of backorder.

2 - Rolling Tree as a Source of Flexibility: Its Added Value in an Agriculture Case

Elbio Avanzini, Pontificia Universidad Catolica de Chile, Santiago, Chile, elavanzini@uc.cl, Alejandro Francisco Mac Cawley, Jorge R. Vera, Lluis Pla, Sergio Maturana

Both the decision support model (DSM) and resources provide flexibility and offer different alternatives to deal with uncertainty. DSM could be different in terms of stages and information requirements. In previous works, we explored the contribution of multistage stochastic programming (MSSP) and the expected value problem (EVP) in a case of fruit harvest under uncertainty, with different flexible resources. In this document, we expanded that work by applying a rolling tree that combines MSSP and EVP. We hope to understand the effects of the structure on the value of the system under uncertainty with known flexible resources, to obtain managerial insights that facilitate the selection of the DSM.

3 - Studying Milkrun Logistics Using Multiple Objective Evolutionary Algorithms

Eduardo Castillo Fatule, The University of Texas at El Paso, El Paso, TX, United States, jecastillofatule@miners.utep.edu, Jose F. Espiritu

Transportation logistics have struggled to adapt to new business models due to a wild increase in demand variability, which can cause problems which traditional approaches can not always address. A deterministic problem is formulated by which multiple objectives can be considered for the formulation of a solution to a milkrun logistics problem. A Multi Objective Genetic Algorithm is created which will try to minimize both total delivery time as well as costs for a small delivery business.

4 - Security Breach and Information Technology Investment

Chengxin Cao, Iowa State University, Ames, IA, United States, ccao@iastate.edu

This paper explores how a firm responses to a security breach happened regarding its information technology (IT) investment. We explore two aspects of information technology, total IT budget, and number of IT employees. We analyze the IT investment change at both the firm- and establishment-level with a panel data of over 3,000 firms and 350,000+ sites from year 2010 to 2016. The analysis shows overall a breached firm invests more in IT after the breach took place. However, the firm does not necessarily invest more in the establishments, unless the establishment is a regional headquarter, close to the headquarter, or in the primary industry of the firm.

5 - Machine Learning Applied to Spectroscopy

Driss Lahlou Kitane, Massachusetts Institute of Technology, Cambridge, MA, United States, driss@mit.edu, Dimitris Bertsimas

Laser Induced Breakdown Spectroscopy plays an increasingly role in in-situ and real time chemical analysis. After irradiating the surface of a material to be analyzed, spectra are collected and use to determine the chemical composition of the material with high precision. We present a novel method using sparse regression to interpret and estimate chemical composition using collected spectra. Presented method significantly improve accuracy and interpretability.

6 - Spatio-temporal Characteristics of Shared Bicycle Riding Based on Data Analysis

Qi Liu, SouthWest JiaoTong University, Chengdu, China, luci20599@163.com, Yong Yin

In order to solve the increasingly serious environmental pressures and energy pressures and reduce pollution and carbon emissions, major cities have actively introduced shared bicycles to alleviate the short-distance travel and “last mile” of residents. This paper selects the data of Mobike cycling in Shanghai in August 2017, and uses Python software and Arc GIS spatial analysis tools to analyze the temporal and spatial distribution patterns and differences of shared bicycle riding in the city, and identify the traffic hotspots and traffic corridors. What’s more, it is connected to the passenger flow of the track line site.

■ WC76

S- Metropolitan Ballroom B

Decision Support Systems II

Contributed Session

Chair: Suman Das, Indian Institute of Technology Kharagpur

1 - Designing a Deceptive Comment Detection Platform with a Rule Based Artificial Intelligent Algorithm

Hongrui Liu, San Jose State University, California, San Jose, CA, 95008, United States, hongrui.liu@sjsu.edu, Arman Toplu

One of the most important factors in a purchasing decision nowadays is the evaluation of comments online. Businesses or individuals use deceptive comments to mislead people for the sake of economic gain and thus hurt the benefit of the customers and the welfare of society. In this research, we propose a rule-based artificial intelligent (AI) machine learning (ML) model for online review fraud detection. The proposed methodology features an AI and ML hybrid architecture, where the AI part prioritizes and customizes the fraud detection rules based on human intelligence to improve the accuracy of the result and increase computational efficiency.

2 - An Early Warning Method Based on the Focus Theory of Choice

Xiuyan Ma, Dalian University of Technology, Dalian, China, max@dlut.edu.cn, Xiangpei Hu

The early warning provides the decision makers with the decision support for the future failures under the uncertainty environment. The warning decision is based on the prior probabilities of possible scenarios and their outcomes, and on the decision maker’s preferences and knowledge. This research proposed a non-expected utility, the focus theory of choice based early warning method. The decision-making process of this method is as follows: anomaly detection, trend analysis of the typical scenario, focus point selection and early warning decision making. The proposed method provides possible solutions of early warning problems in the internet of things environment.

- Mathematical Optimization for Habitable Layout Design Driven by Psychophysical Criteria

Claudia Ramirez-Wade, University of North Carolina-Charlotte, Charlotte, NC, United States, cramir16@uncc.edu, Simon Hsiang, Churlzu Lim

We evaluated different spacecraft layout designs based on psychophysical attributes correlated to proximity and functionality of identified task volumes to minimize volume while maximizing the crewmembers’ health, performance, and safety for the duration of a mission to Mars. The objective of the evaluation model is to help decision makers reach a decision by looking at every need and design strengths of the layout by comparing layouts on its overall effectiveness in relation to all of its needs. The proposed model is a mapping reference between physical arrangements and the psychophysical satisfaction of needs that provides greater insight in the design of the layout based on mission parameters.

4 - Predicting Dairy Cow Milk Yield in Early Lactation by Applying Convolutional Neural Networks on Sequential Information

Arno Liseune, Ghent University, Ghent, Belgium

In this research, we present a framework that predicts a cow’s milk yield in early lactation. In particular, we show how convolutional neural networks are able to uncover a relationship between a cow’s milk yield in the first days after calving and preceding sequential information such as milk yields and health events. In addition, we investigate if the inclusion of herd information enhances the predictive performance. The results presented in this research can be used to detect anomalies between a cow’s expected and true milk yields, hence enhancing current animal monitoring systems.

5 - Necessity of Fuzzy Geometry in Fuzzy Interpolation

Suman Das, Research Scholar, Indian Institute of Technology Kharagpur, Kharagpur, India, pnksmdas@gmail.com, Debjani Chakraborty

A series of works on fuzzy geometry has gained its existence on establishing the fact that a hazy object in the space can be visualized as fuzzy point. The locus of fuzzy point is captured efficiently with fuzzy geometry. In order to explore its applicability, fuzzy interpolation has been chosen a field of study. A rule base can be visualized as combination of fuzzy points. The dimension is dependent on the total number of antecedents and consequents in a rule. Thus fuzzy geometry provides a tool to accommodate an unknown antecedent or consequent in the rule base. A methodology has been developed to capture the behaviour of fuzzy rule base and a discussion has been initiated to facilitate fuzzy interpolation.

■ WC77

S- Fremont

Non Profit and New Product Development

Contributed Session

Chair: Jue Liu, Nanjing University

1 - Network Structures and Sustainability of Joint Liability: Authoritarian vs Egalitarian Networks

Bahar Rezaei, UCLA Anderson School of Management, Los Angeles, CA, United States, rezaei@ucla.edu

Lack of well functioning formal institutions leads to reliance on borrowers’ social networks to enforce group lending contracts with joint liability. We develop a model in which connections between borrowers serve as monitoring tools and examine the effect of various borrower network structures, especially decentralized and centralized networks, on the performance of a joint liability group. Our results show that while for smaller groups, the highly decentralized ring networks (egalitarian) may have a higher performance than the highly centralized star networks (authoritarian), for larger groups, star networks outperform the rings.

2 - The Impacts of Mergers, Capacity Expansion and Adoptions on Animal Shelter Performance: a Queuing Analysis

Janice Carrillo, University of Florida, Gainesville, FL, United States, Nazli Turken, Anand Paul

In this paper, we define, compare and perform a sensitivity analysis of performance metrics involving Erlang loss queues. We capture a unique reneging and retainment process germane to the euthanization practices typically utilized by traditional animal shelters. We ultimately provide recommendations for animal shelters on the most efficient investments and analyze the effects of mergers and capacity expansion on various performance metrics. Furthermore, we expand our model to incorporate state dependent euthanization processes.

3 - Social Enterprise Welfare and New Product Diffusion: Model and Empirical Validation at World Bicycle Relief

Vadim Glinskiy, PhD Student, Kellogg School of Management, Evanston, IN, United States, vadim.glinskiy@kellogg.northwestern.edu, Jan A. Van Mieghem

We present a dynamic model of a social enterprise (SE) that offers a product through its not-for-profit and for-profit channels. Product offered in either channel stimulates future market (for-profit) demand. We present a continuous-time, 2 channel product diffusion model and a closed-form expression for the optimal production policy. We perform sensitivity analysis on two conflicting objectives: maximize social welfare or profitability. Our theoretical results are validated with a rigorous empirical study of World Bicycle Relief. We find conditions for which the for-profit channel can increase social welfare and the not-for-profit channel can increase profitability.

4 - Product Innovation in the Presence of Strategic Consumers with Uncertainty About New Product

Jihyun Hong, PhD Candidate, Korea University Business School, Seoul, Korea, Republic of, hjhheehee@korea.ac.kr, Kyungsam Park

In a situation where a firm releases a new product with new attributes and a previous model of the same product coexists, we study the effect of strategic purchase decisions of consumers who are uncertain about their future needs of new attributes on the firm's strategy for product innovation.

5 - Crowdfunding for New Product Development: The Role of Information Disclosure

Jue Liu, Nanjing University, Nanjing, China, hiliujue@hotmail.com, Houcai Shen

This study examines the strategic role and value of information disclosure in crowdfunding for new product development with quality uncertainty. In such a crowdfunding campaign, disclosing information about early investors' decisions allows late investors to update their beliefs based on the observations of the early investors' behavior. We show that if the target is sufficiently high or sufficiently low, information disclosure increases the expected total investment. Otherwise, information disclosure decreases the expected total investment.

■ WC78

S- Greenwood

Big Data III

Contributed Session

Chair: Hyunsang Son, The University of Texas at Austin, Fort Collins, CO, 80525, United States

1 - Using Customer Behavior Big Data to Optimize Collection and Delivery Points for Online Retailers

Yeming Gong, Professor, Em Lyon Business School, Ecully, France, gong@em-lyon.com, Yaohan Shen, Xianhao Xu, Wanying Chen

While previous delivery points optimization researches do not use customer behavior data, we propose a new procedure, integrating with customer behavior data analysis, to optimize collection and delivery points for online retailers. Our research shows an optimal approach to locate attended and unattended collection and delivery points such that online retailers can trade off consumer service level and the total logistics cost. We extract feature set from raw customer behavior data which decides the upper bound of a prediction algorithm's performance, and regard outputs of state-of-art purchase prediction algorithm as the demand level of customers in each period.

2 - Data-driven Platform-based Supply Chain Management: Eco-label Standard Design and Competition Strategy

Sijie Zhou, University of Science and Technology of China, Hefei, China, zhsijie@mail.ustc.edu.cn, Yugang Yu

This paper is motivated by practical example of a furniture trade platform, to certify the most environmental furniture brands. We explore the operational data and analyze the causal effect of eco-label through DID approach with machine learning. Our analytical model shows that. If there are 2 quality-heterogeneous firms, the optimal standard is equivalent to high quality and the labeled brand won't rise price. Our results demonstrate platform must set the standard near the expectation of the total firms' quality with a continuous quality distribution for many firms. This paper is the first that regards platform as certifier and considers the dependence between quality and eco-label stringency.

3 - The Number of Tourists Prediction Between Cities

Yuquan Xu, XI'an Jiaotong University, Xi'an, Shaanxi, China

Travel prediction between cities is a widely application among many tourism research topics, such as travel package design. This paper propose a method to predict trourists' flow between cities. It can bring benefit to tourism research and promote tourism development.

4 - Predicting Genotype-by-environment (GxE) Interaction Effect Using Genetic Marker Predictors

Samira Karimzadeh, Graduate Research Assistant, Iowa State University, Ames, IA, United States, samirak@iastate.edu, Sigurdur Olafsson

In application of machine learning in plant breeding, predicting yield of a seed variety based on past observations is a big challenge. Since the yield is a function of genotype-by-environment called GxE effect, sufficiency of the past observations in target environments is crucial in building the prediction model. When observations of the target variety is not enough to train a model, using observation of related varieties those have same GxE behavior could be a possible solution. In this study, we have developed a supervised prediction model to identify related varieties using genetic marker predictors when there is no yield observation available to identify related varieties based on GxE effect.

5 - What Did People Seek and Share in Natural Disasters

Hyunsang Son, The University of Texas at Austin, Austin, TX, 78701, United States, hyunsangson@utexas.edu, Jisoo Ahn, Arnold Dongwoo Chung

This study applies a community detection method utilizing infinite edge partition models to observe the information-spreading patterns during an earthquake in Japan. The findings of communication hubs in the social networks can help practitioners understand the flow of information and prepare more effective message strategies during natural disasters.

6 - Change Point Detection in Partial Correlation Networks

Jessica Wai Yin Leung, University of Sydney, Sydney, Australia, jessica.leung@sydney.edu.au, Dmytro Matsypura

We study the change point detection problem in similarity network over time. Correlation matrix is commonly used in constructing similarity networks. Yet, it is well-known that it suffers from the illusion of spurious relationships within the system. Therefore, we adopt partial correlation as an alternative measure and developed a statistical testing procedure with minimal distributional assumption. Preliminary simulation results shows high statistical power across different sample sizes and dimensions.

■ WC79

S- Issaquah A

Energy V

Contributed Session

Chair: Panagiotis Andrianesis, Boston University, Brookline, MA, 02446, United States

1 - A Data Mining Topology Control Heuristic for Post-Contingency ACPF Violation Reduction in Real World, Large Scale Systems

William Eric Brown, Texas A&M University, College Station, TX, United States, webrown@tamu.edu, Erick Moreno-Centeno

Topology control (TC) has proven a useful recovery technique for post-contingency power grid operations. However, because of concerns over computational complexity, uncertain AC performance, and real world scalability, TC remains implemented only in limited capacity. This work proposes a data mining heuristic to identify TC actions which reduce post-contingency AC power flow violations. Tested on real world power system data, the proposed method significantly outperforms current distance-based heuristics. For voltage magnitude violations, we identify optimal actions in over 97% of studied instances and attain an average search depth roughly one tenth that of distance-based heuristics.

2 - Distribution Electricity Pricing under Uncertainty

Robert Mieth, New York University, Brooklyn, NY, United States, robert.mieth@nyu.edu, Yury Dvorkin

Distribution locational marginal prices (DLMPs) facilitate the efficient operation of low-voltage distribution systems. We propose an approach to internalize the stochasticity of renewable resources and risk tolerance of the distribution system operator in DLMP computations. This is achieved by means of applying conic duality to a chance-constrained AC optimal power flow. We show that the resulting DLMPs consist of the terms that allow to itemize the prices for the power production, balancing regulation, and voltage support provided. Finally, we prove the proposed DLMP constitute a competitive equilibrium, which can be leveraged for designing a distribution electricity market.

3 - Networked Synthetic Dynamic PMU Data Generation: A Generative Adversarial Network Approach

Dileep Kalathil, Assistant Professor, TAMU, College Station, TX, United States, Xiangtian Zheng, Dongqi Wu, Le Xie

Due to the confidentiality of real PMU data and no public access to detailed real power systems model, the lack of credible PMU data becomes a growing concern for research and education purposes. In this paper, using partial power systems infrastructure information, we develop a GAN-based method to synthesize realistic networked PMU data, which satisfy basic physics laws and mimic dynamic behavior of simulated power system. We validate the realistic dynamic characteristics of networked synthetic PMU data via a modal analysis method.

4 - Effect of UHV Grid on the China Power Market: A Parameterized Supply Funciton Equilibrium Analysis

Kaiying Lin, Johns Hopkins University, Baltimore, MD, United States, Southeast University, Nanjing, China, Beibei Wang, Chang Xie, Benjamin Field Hobbs

We consider a supply function equilibrium for the power market under the proposed UHV (Ultra High Voltage) grid in China. Parameterized supply functions for energy and spinning reserves are considered. Diagonalization is used to obtain equilibria among generators' unit commitment problems. We simulate the effect of assumptions concerning network congestion, load growth, import power characteristics, reserve activation payments, reserve cost allocation, market power mitigation, and alternative network configurations. Results of Q-learning algorithms for obtaining equilibria are also compared.

5 - Market Value of HVDC Corrective Control Capabilities

Andrea Tosatto, Technical University of Denmark, Kgs. Lyngby, Denmark, antosat@elektro.dtu.dk, Stefanos Delikaraoglou, Jalal Kazempour, Spyros Chatzivasileiadis

To guarantee a safe operation of power systems, TSOs enforce the N-1 security criterion. If no recourse actions are considered, the resulting dispatch is extremely expensive. By controlling power flows, HVDC lines can help accommodate the new situation, avoiding costly generation redispatching. This service can be offered if part of HVDC capacity is reserved, and not used for energy trading. Thus, it should be provided at a cost, especially in the case of merchant lines. The scope of this work is to determine the value of HVDC corrective control and how HVDC line owners can benefit from it.

6 - A Hierarchical Decomposition Approach for Optimal Grid – Distributed Energy Resource Coordination

Panagiotis Andrianesis, Boston University, Brookline, MA, United States, panosa@bu.edu, Michael C. Caramanis

In this work, we present a hierarchical decomposition approach that is based on centralized AC Optimal Power Flow capability interacting with Distributed Energy Resource (DER) self-dispatch that adapts to real and reactive power distribution locational marginal costs. We illustrate that the discovery of spatiotemporally varying marginal costs in distribution networks, which apart from network congestion also reflect asset degradation, is key to optimal DER scheduling. We discuss the applicability and tractability of the proposed approach on actual distribution feeders, while modeling the full complexity of spatiotemporal DER capabilities and preferences.

■ WC80

S- Issaquah B

Simulation I

Contributed Session

Chair: Valeria Puyo, Universidad de los Andes

1 - Nonparametric Tests for Convexity, Monotonicity, or Positivity of Multivariate Functions with Noisy Observations

Eunji Lim, Assistant Professor, Adelphi University, Garden City, NY, United States, elim@adelphi.edu

We propose a new method of testing for a function’s convexity, monotonicity, or positivity, based on noisy observations of the function over a finite set T of points in the domain, where the observations can be made multiple times at each point in T. The proposed method fits a convex, monotone, or positive function to the data set and examines the sum of squared differences between the fit and the data set as the number of observations taken at each point in T increases to infinity. This leads to a test procedure that does not require the estimation of any additional parameters, and hence, does not need any artificially plugged-in parameters. Theoretical properties and numerical results will be presented.

2 - Drivers’ Perception of Headways in the Operations of Connected and Autonomous Vehicles

Yujie Li, Purdue University, West Lafayette, IN, United States, li2804@purdue.edu

This study proposes an innovative psychological method to investigate drivers’ perception of headways at Level 3 automation, which is important to achieve a good balance between mobility and user experience. The experiments are carried out using a driving simulator that can transition between AV mode and manual mode. In addition, participants’ physiological data were collected to reinforce their subjective response data. Pilot test data were also collected. The results indicate that multiple headway thresholds can be estimated and that, drivers’ attitudes towards the AV operations can be inferred.

3 - A Simulation Model of Staffing Decisions for Wafer Ingot Manufacturing

Yu-Han Ke, National Chiao Tung University, Hsinchu, Taiwan, yhke.iem07g@nctu.edu.tw, Sheng-I Chen

We consider the staffing decision in an ingot manufacturing plant, where there are types of machine to produce products in different diameters and dopant chemicals. A crystal growing process involves a serial of activities, and each of them requires a different number of operators. The overall duration of the process and runs in each batch are uncertain. Operators are required to set up the equipment and refill raw materials whenever starting a new batch. Also, activities of moving and equipment maintenance are performed by labors periodically. We develop a simulation model to capture the above considerations. The model is applied for assessing personnel allocation under various facility layouts.

4 - Impact Analysis of Over Tourism by Multi-agent Simulation

Ichirota Nakada, Waseda University, Tokyo, Japan, Takashi Hasuike

Japanese government has been focusing on the tourism industry since about fifteen years ago, and the increase in the number of foreign tourists in recent years is striking. Over-tourism however has become a trend word in various parts of the world in recent years, and even in Japan, the adverse effects on residents of tourist spots are being scattered. So, in this research, in order to analyze the various influences on the tourist destination by over tourism, we build a dynamic model by agent simulation. And the purpose is to get more realistic hints of strategies for solving problems.

5 - Teaching Monte Carlo Simulation for Retirement Planning

Chester G. Chambers, Associate Professor, Johns Hopkins University, Baltimore, MD, United States, cchamber@jhu.edu

The distribution phase of retirement planning is a very hard problem that has received great interest from anyone planning to retire in the coming years. Students are overwhelmed with biased information regarding spending rules and failure rates. We address student needs with a case designed to evaluate common withdrawal rules, asset allocation, utility maximization, and the role of leverage in the allocation process. This case is intended for MS and MBA audiences and is delivered using either Excel as a simulation platform or R as a coding language.

6 - Analytics Framework to Improve People Flow on Large Buildings

Valeria Puyo, Universidad de los Andes, Bogotá, Colombia, v.puyo@uniandes.edu.co, Liseth Daniela Grosso, Jorge Huertas, Diego Monroy, Maurix Suárez, Andres L. Medaglia

Improving the people flow in congested buildings is relevant when planning disaster mitigation strategies that might ultimately save lives. To improve people flow in large buildings we propose an analytics framework comprised of three layers. In the descriptive layer, we collect data and estimate the building’s origin-destination matrix, which is the input of a discrete-event simulation model that recreates the flow dynamics. In the predictive layer, we simulate scenarios varying the traffic and load of the building to measure the impact on congestion. Finally, in the prescriptive layer, we simulate several infrastructure interventions and recommend actions that relieve congestion.

■ WC81

S- Kirkland

Resource Allocation & Climate Change

Contributed Session

Chair: Tetsuya Tamaki, Kagawa University, Fukuoka City, 8190395, Japan

1 - Two-sided Assortment Optimization

Asrar Ahmed Mohammed, Indian School of Business, Hyderabad, India, asrar_ahmed@isb.edu, Milind Sohoni, Chaithanya Bandi

We consider the problem of online service platforms which match job applicants with potential employers. Unlike traditional formulations which treat the participants as passive, we allow both employers and job applicants to exercise their choice. We introduce a two sided assortment optimization model which captures the platforms constraint that it can only provide recommendations to each participant. We present a mixed integer linear programming formulation of the model and provide performance bounds for a greedy online algorithm that can be solved efficiently. The algorithms are evaluated on real-world dataset from a leading freelancing platform

2 - Re-planning Airport Infrastructure and Operating Practices with Information from Simulation Modeling

Anthony Gerard Vatterott, University of Missouri-Saint Louis, Saint Louis, MO, United States, anthonygvatterott@gmail.com, Liang Xu, Canser Bilir, Laurence Douglas Smith

De-hubbing by major airlines has left many U.S. airports operating with traffic volumes that differ dramatically from projections used when developing their infrastructure. We describe the application of a discrete-event simulation model to assess the impact on individual carriers if airport resources were re-purposed and operating practices were changed in an effort to contain costs at an airport with excess capacity.

3 - Optimizing Dynamic Green Infrastructure Placement in an Urban Watershed: A Distributionally Robust Approach

Masoud Barah, Northwestern University, Evanston, IL, United States, mbarah@northwestern.edu, Anahita Khojandi, Xueping Li, Jon Hathaway

Green infrastructure are mostly implemented in a reactive manner instead of being incorporated as a coherent part of urban spatial planning. Here we develop a mathematical model to optimally place GI practices when (re-)designing an urban area, subject to uncertainties in population growth and future precipitation. Specifically, we develop a distributionally robust finite-horizon Markov decision process model to determine the extent to which GI practices need to be incorporated in different parts of a given urban area to maximize their benefits, considering the dynamic changes in population density and precipitation. We conduct a case study, perform sensitivity analyses and provide insights.

4 - Regulation of CO2 Emissions for Each Area in a Region

Tetsuya Tamaki, Dr., Kagawa University, Kagawa, Japan, tamaki@eng.kagawa-u.ac.jp

This study proposes a model analyzing the economic impacts of global warming in a region to maintain the consistency of the global model. This model estimates best regulations for each area in a region under the condition that the upper limit of emission is given by a global model. We analyze the case of Japan and find that more developed areas should implement stricter regulations in all scenarios. However, the policy by area scenario is not always preferable than that of policy by region (comprising multiple areas). The policy by area scenario results in disparities in the region and may decrease the total output even if the total utilities increase.

■ WC82

S- Leschi

Joint Session ENRE/SOLA: OR Applications in Energy and Transportation Sectors

Sponsored: Energy, Natural Res & the Environment/Environment & Sustainability

Sponsored Session

Chair: Yihsu Chen, University of California-Santa Cruz, Santa Cruz, CA, 95064, United States

Co-Chair: Yu Zhang, University of California-Santa Cruz, Santa Cruz, CA, 95064, United States

1 - Electricity Markets in Presence of Strategic Prosumers

Sepehr Ramyar, University of California Santa Cruz, Santa Cruz, CA, United States

We investigate the formation of wholesale power prices in presence of strategic prosumers and analyze how the unconventional behavior of agents capable of consumption and generation at the same time can impact wholesale power markets. In this study, the price is determined endogenously by strategic prosumers along with other market participants. We study the behavior of prosumers in Stackelberg formulation of the induced game in the power market with the prosumer as the leader and other agents as followers. We discuss and report the ensuing market outcomes and contrast it with other strategies by the prosumer.

2 - An Integer Programming Approach to Optimal Load Shedding

Yu Zhang, Assistant Professor, UC Santa Cruz, Santa Cruz, CA, 4592921, United States, zhangy@ucsc.edu, Masoumeh Ghanbarpour, Scott Moura

In this talk, we provide an optimization framework for stochastic optimal load shedding in networked microgrids that include heterogeneous load zones. Considering uncertain estimates of power consumption and energy shortfall, we formulate the system planning task as a chance-constrained integer quadratic program. By leveraging binary decomposition and McCormick relaxations, we develop two efficient algorithms yielding minimum total load shedding cost while respecting fairness among end users. Simulation results corroborate the merits of our proposed framework and algorithms, which outperform the off-the-shelf solver BARON.

3 - Environmental Policy in Maritime Transport Sector: Vertical Integration and Competition

Mari Ito, Tokyo University of Science, Chiba, Japan, Ryuta Takashima

In this work, we propose a model of economic evaluations for the vertical integration of shipping and port firms. In a social welfare analysis, maritime emission regulations are comprehensively examined. We also analyze the effect of emission control at partial region on total emissions and surplus of shipping and port firms. We have found that it is preferable to regulate the integrated route from the viewpoint of social welfare.

4 - Optimal Configuration of Air Conditioning System by Using Statistical Method and Machine Learning

Haruki Inoue, Osaka University, Suita, Osaka, Japan, Yuta Izumi, Hiroshi Morita

We consider the equipment configuration to minimize energy consumption. Energy consumption is calculated by computer simulation and hard to handle. We propose an efficient iterated local search algorithm for the black box optimization problem. We reduce the calculation time of the black box function by using extreme statistics and lasso regression. Training data are given from the results of simulation obtained in iterated local search. The proposed method is applied to the optimization of the air conditioning system configuration.

■ WC83

S- Medina

Recent Developments on Optimization of Grid Integrated Energy Storage

Sponsored: Energy, Natural Res & the Environment/Electricity

Sponsored Session

Chair: Qifeng Li

1 - Market Evaluation of Energy Storage Systems Incorporating Technology-specific Nonlinear Models

Tu Nguyen, Senior Member of Technical Staffs, Sandia National Laboratories, Albuquerque, NM, 87185, United States, tunguy@sandia.gov

This presentation provides an overview of technology-specific nonlinear energy flow models based on nonlinear operating characteristics of the storage devices. These models are incorporated into an optimization problem to find the optimal market participation of energy storage systems. A dynamic programming approach is used to solve the optimization problem. Two case studies are conducted for maximizing the revenue of a Vanadium Redox Flow Battery (VRFB) and a Li-ion battery system in PJM’s energy and frequency regulation markets.

2 - Energy Storage Management via Deep Q-Networks

Ahmed Zamzam, National Renewable Energy Laboratory, Golden, CO, 55455, United States, ahmed.zamzam@nrel.gov

We study the problem of real-time control of storage units installed in distribution grids with integrated renewable energy generation. Unlike many previous approaches, no distributional assumptions are being made on the renewable energy generation or the real-time prices. Building on the deep Q-networks algorithm, a reinforcement learning approach utilizing a neural network is devised where the storage unit operational constraints are respected. The neural network approximates the action-value function which dictates what action to take. Simulations indicate that near-optimal performance can be attained with the proposed learning-based control policy for the storage units.

3 - Stochastic, Robust and Distributionally Robust Dispatch of Smart Buildings Loads

Yury Dvorkin, New York University, Metrotech Center, NY, 11201, United States, dvorkin@nyu.edu

Controllable electrical appliances in smart buildings can adjust their consumption to help meeting operational power grid limits. However, the dispatchable flexibility of these appliances depends on the ability to accurately model their behavior. This presentation describes an approach to dispatch an ensemble of smart buildings using the Markov Decision Process framework immunized against uncertain buildings and appliances parameters. This robustification is considered under different statistical assumptions using methods from stochastic programming, robust and disitrbutionally robust optimization, which leads to different analytical and/or numerical dispatch policies.

4 - A Convex Nonlinear Model for Grid-integrated Battery Energy Storage

Qifeng Li, University of Central Florida, Orlando, FL, 32816, United States, qifengli@mit.edu

Battery energy storage (BES) is considered an essential component of future power systems. The convexification of mathematical models of another essential power system component, i.e. the power networks, has been widely studied in the past decade. In this talk, we will talk about the convexification of BES models: first, a nonlinear model of BES units is developed based on an equivalent BES circuit; then, a tight convex relaxation for this nonlinear model is introduced; finally, with the developed convex BES model, we build a convex model for grid optimization considering BES units.

■ WC84

S- Ravenna A

Coordination and Operation of Integrated Energy Systems

Sponsored: Energy, Natural Res & the Environment/Energy Sponsored Session

Chair: Jalal Kazempour, Technical University of Denmark, Kgs Lyngby, 2800, Denmark

Co-Chair: Spyros Chatzivasileiadis, Technical University of Denmark, Kgs. Lyngby, 2800, Denmark

1 - Flow Solvers for Natural Gas and Water Distribution Networks

Manish Singh, Virginia Tech, Blacksburg, VA, United States, Vassilis Kekatos

Natural gas and water distribution networks are interconnected with electric power systems since gas compressors and water pumps needed to regulate pressure run on electricity. At the heart of operating these networks, lies a set of nonlinear flow equations. These equations are shown to enjoy a unique solution. Moreover, if compressors and pumps do not occur in loops, this solution can be found via convex minimization. For more general setups, solving the flow equations is posed as a mixed-integer non-convex minimization, which is relaxed to an MIQP. The relaxation is shown to be exact in networks with non-overlapping loops or if overlapping loops do not involve compressors and pumps.

2 - Pipeline Transient Optimization for A Gas-electric Coordination Decision Support System

Anatoly Zlotnik, Los Alamos National Laboratory, Los Alamos, NM, United States, azlotnik@lanl.gov, Alexandr M. Rudkevich, Pablo A. Ruiz, Richard D. Tabors, Xindi Li, Charles Russell Philbrick, Alexandr Beylin, Kaarthik Sundar

Transient optimization of gas pipelines has experienced a resurgence of interest inspired by the need to coordinate intraday operations of wholesale electricity and natural gas transmission networks. An organized exchange of information between optimization-based auction markets for scheduling energy production and delivery over these systems is increasingly critical. Economically and operationally efficient intraday coordination will require assimilation of real-time data to produce real-time optimization-based solutions. This talk will describe such mechanisms, recent validation studies, and research needs for a future decision support system for gas transportation.

3 - Chance-constrained Coordination of Power and Natural Gas Systems: A Conic Relaxation Approach

Anubhav Ratha, PhD Student, Technical University of Denmark, Kgs Lyngby, 2800, Denmark, arath@dtu.dk, Jalal Kazempour, Pierre Pinson, Ana Virag, Ana Virag

Accessing flexibility from coordinated dispatch of power and natural gas is a promising solution to increase renewable energy share in power systems. We implement a chance-constrained co-optimization of power and natural gas operation wherein flexibility from short-term gas storage in pipelines ('linepack') is made accessible to power systems. The non-linear and non-convex equations governing flows in power and gas networks are convexified using DC power flow approximation and second-order cone relaxation, respectively. Recourse actions, based on linear decision rules, allow adjustments to dispatch during real-time operation when uncertainty in demands and productions is revealed.

4 - A Heat Unit Commitment Model with Power Systems Awareness

Lesia Mitridati, PhD, Georgia Institute of Technology, Atlanta, GA, United States, lmitridati3@gatech.edu

The penetration of stochastic renewable energy production in power systems can be facilitated by exploiting the sources of flexibility at the interface with other energy systems, such as heat. Therefore, we introduce an electricity-aware heat unit commitment model for the coordination of heat and electricity systems. The sequential heat and electricity markets are modeled as lower-level problems. In the upper-level problem, the heat unit commitment relies on bid validity constraints to endogenously model the interactions between heat and electricity markets. The resulting trilevel optimization problem is recast as a single-level problem using a lexicographic order and strong duality.

■ WC85

S- Ravenna B

Electrified Transportation: A Rising Nexus

Sponsored: Energy, Natural Res & the Environment/Energy Sponsored Session

Chair: Matteo Muratori, NREL, Golden, CO, 80401, United States

1 - Electrified Transportation: A Rising Nexus

Matteo Muratori, NREL, Golden, CO, 80401, United States, matteo.muratori@nrel.gov

After over a century of petroleum dominance, many anticipate major electrification trends that could disrupt the transportation landscape. These changes complement profound changes happening within electric systems: the traditional system based on the premise that generation is dispatched to match demand is evolving to create a system with greater participation in power system planning and operations from traditionally passive consumers. This broader context underscores the importance of understanding how transportation electrification will impact electricity demand, including changes in the load shapes and the opportunity to leverage flexible EV charging to balance demand and supply.

2 - Power Sector Capacity Expansion Modeling of an Electrified Energy System

Trieu Mai, National Renewable Energy Laboratory, Golden, CO, United States, trieu.mai@nrel.gov

Electrification can alter both the shape and the amount of electricity consumption. Adoption of heat pumps could introduce new winter peaks while transportation electrification introduces a new source of demand altogether. Moreover, electrification could shift natural gas consumption between sectors, thereby affecting the economics for natural gas-fired generation. Electrification could also amplify opportunities for demand-side flexibility. Here, we present our representation of these effects in the Regional Energy Deployment System (ReEDS) model, an optimization-based power sector capacity expansion model used in the Electrification Future Study.

3 - Distribution System Constrained Vehicle-to-Grid Services

Sunil Chhaya

Please check the mobile app for this abstract.

4 - Optimized Charging of Electric Vehicles in on Demand Mobility Services

Jonathan Donadee, Research Engineer, Lawrence Livermore National Laboratory, Livermore, CA, United States, donadee1@llnl.gov, Brenden Petersen

In this work, we apply deep reinforcement learning to optimize the driving and charging strategy of an electric vehicle that operates in an on-demand mobility service, such as ride-hailing. The optimal strategy seeks to minimize electric energy costs and emissions while maximizing mobility service provided and resilience to charging station congestion and outages. Results are presented for a test case with mobility demand modeled on New York City taxi and with a solar power generation dominated electric grid.

5 - Advances in Integrating Hydro-climate Research in Regional Power System Analytics

Nathalie Voisin, Pacific Northwest National Laboratory, Seattle, WA, United States, Nathalie.Voisin@pnnl.gov

As the grid is changing with increasing integration of renewables, evolving markets and technology innovation, the conceptual and highly parameterized representations of hydropower and thermo-electric plants are challenged. Advances in integrating hydro-climate research through enhanced parameterization and physics based processes in regional power system analytics are presented through a series of numerical experiments. The Western U.S. water-energy dynamics are simulated using combinations of scale-appropriate hydrological-water management-production cost models to evaluate opportunities in short to long term energy planning and water-energy trade offs.

■ WC86

S- Ravenna C

E Business/Commerce II

Contributed Session

Chair: Yumeng Miao, Xidian University

1 - The Effects of SNS Advertisement Attributes on Product Image and Purchase Intention According to Consumption Propensity

Eunju Ahn, Kyungpook National University-Korea, Daegu, Korea, Korea, Republic of, dmswn8808@naver.com, SungSu Kim

This research's purpose is to investigate the effects of product advertisement on product image and purchase intention through SNS. In particular, the emphasis is on moderating effects of consumption propensity. SNS advertising has the characteristic of inducing consumers' interest rather than searching for the product to buy by themselves. Therefore, it is necessary to study what kind of strategies should be established according to consumers' propensity to consume. We present the SNS advertising strategies by consumption propensity through the analysis of the structural equation model.

2 - How Do Country Characteristics Affect Cross-border E-commerce Sales in Europe? An Empirical Study

Nevin Mutlu, Eindhoven University of Technology, Eindhoven, Netherlands, n.r.mutlu@tue.nl, Zohreh Khooban, Sarah Gelper, Ton de Kok

One of the priorities of the European Commission is to establish a Single Digital Market in Europe, where customers can seamlessly make online purchases from other countries. The objective of this study is to develop insights that aid retailers and policy-makers in decision-making towards establishing a Single Digital Market in Europe. Towards that end, we conduct an empirical analysis using a unique dataset on the European consumers' cross-border shopping behavior. Specifically, we examine how country characteristics at the economic, regulatory, and cultural levels moderate the effects of individual-level drivers of cross-border sales.

3 - The Effects of Guanxi Circles for Customer Entrepreneurs on Social E-commerce Platforms

Yumeng Miao, Xidian University, Xi'an, China, ymmiao@stu.xidian.edu.cn

Recent practice shows that companies can diffuse new products faster by encouraging customers to share products knowledge in social media and transforming them into salesforce. We conducted a case study in an electronic commerce company to explore how different guanxi circles embedded in social media work for customer entrepreneurs' knowledge sharing and the role of cloud business platform in helping them get benefits. We found that guanxi-based knowledge sharing via WeChat consists of familial, familiar, and acquaintance ties, which subsequently helps realize physical, psychological, economic, and social benefits, but with the exception of familial ties' modest role along with the process.

4 - Three-stage Dynamic Game for Logistics Decision with Self-run Logistics and Unmanned Aerial Vehicle

Sun Qi, Shanghai Jiao Tong University, Shanghai, China, sun_qi@sjtu.edu.cn

In this paper, the e-commerce logistics capability decision system is divided into self-run logistics and unmanned aerial vehicle (UAV). The uncertainties of e-commerce orders are described as the main source of systematic noise, and then three kinds of flexible intensity supplement of UAV distribution capability are designed to deal with different situations for capability decision system. The three-stage dynamic game model is proposed in three cases, so that the decision maker can choose the best operation scheme on the basis of the change of unit cost of UAV distribution.

Wednesday, 3:20PM - 4:50PM

■ WD01

CC- Room 201

Machine Learning: Theory and Applications

Sponsored: Data Mining

Sponsored Session

Chair: Theja Tulabandhula

Co-Chair: Danial Mohseni-Taheri, University of Illinois at Chicago, Chicago, IL, 60610, United States

1 - Overbooking in Network of Energy Storage

Danial Mohseni-Taheri, College of Business, University of Illinois at Chicago, Chicago, IL, 60610, United States, Selvaprabu Nadarajah, Theja Tulabandhula

Ethanol production has increased in the past few years and can also be sourced globally (e.g., Brazil), which results in regular supply and demand imbalances that are handled by storage assets. Storage service providers sell capacity to users via long-term contracts and need to deal with the under-utilization of their assets during supply droughts and high usage during supply gluts. Motivated by a large US ethanol storage provider, we study the overbooking of capacity in a network of storage assets by considering the parameters of the users.

2 - Confounding-Robust Policy Improvement

Angela Zhou, Cornell University ORIE, 206 Rhodes Hall, Ithaca, NY, 14853, United States, az434@cornell.edu, Nathan Kallus

We study the problem of learning personalized decision policies or estimating heterogeneous treatment effects from observational data while accounting for possible unobserved confounding in the data-generating process. We calibrate policy learning for realistic violations of this unverifiable assumption with uncertainty sets motivated by sensitivity analysis in causal inference. For estimation of individual causal effects, we develop a functional interval estimator. We prove that if the uncertainty set is well-specified, our policy is asymptotically minimax-optimal, and demonstrate improvement and robustness on case studies from clinical trials.

3 - A Single Time-scale Stochastic Approximation Method for Nested Stochastic Optimization

Saeed Ghadimi, Princeton University, Princeton, NJ, United States, sghadimi@princeton.edu, Andrzej Ruszczynski, Mengdi Wang

We propose a single time-scale stochastic approximation algorithm, which we call the Nested Averaged Stochastic Approximation (NASA), for solving nested stochastic optimization (NSO) problems in which the objective function is a composition of two functions whose exact information are not available. We show that NASA achieves the sample complexity of $O(1/\epsilon^2)$ for finding an ϵ-approximate stationary point, thus outperforming all extant methods for NSO. Our method and its analysis are the same for both unconstrained and constrained problems, without any need of batch samples. This property makes NASA attractive for online learning where samples are received one by one.

4 - Prior-aware Spectral Inference for Co-occurrence Modeling

Moontae Lee, Assistant Professor, Universitty of Illinois at Chicago, Chicago, IL, United States, moontae@uic.edu

Spectral inference operate on matrices/tensors of co-occurrence statistics to learn low-dimensional geometries such as topics of documents or communities of networks. These algorithms are efficient and provable, but can no longer learn low-dimensional compositions of individual examples. Thresholder Linear Inverse is developed to map observations back to their latent compositions. But its linear characteristics limit inference quality without considering latent correlations. This talk proposes Prior-Aware Dual Decomposition/Manifold Iteration that leverage the latent correlations as a generic prior successfully on various data, completing the missing half of spectral inference.

5 - Learning to Partition Using Score Based Compatibilities

Theja Tulabandhula, UIC, FF07 Ajanta Vihar, Yelahanka, Chicago, IL, United States, Arun Rajkumar, Koyel Mukherjee

We study the problem of learning to partition users into groups, where one must learn the compatibilities between the users to achieve optimal groupings. We define objectives that optimize for compatibilities and propose algorithms for adaptively learning optimal partitions. We show that in general, the group formation objectives considered are NP hard to solve, and we either give approximation guarantees or prove inapproximability results. We then introduce an elegant structure, namely that of intrinsic scores, that makes many of these problems polynomial time solvable. We also propose an online low sample complexity PAC algorithm for learning the optimal partitions.

WD02

CC- Room 202

Data Analytics for Supply Chain Optimization

Sponsored: Data Mining

Sponsored Session

Chair: Ashton Kappelman

1 - Optimal Control in Food Supply Chain Using Big Data

Ashton C. Kappelman, Kansas State University, Manhattan, KS, 66506, United States, kappelmana@ksu.edu, Ashesh Sinha

We consider a dynamic food supply chain with multiple process steps and model it as a Markov Decision Process. The decisions at each step include supplier selection and settings for their process parameters. We propose an integrated approach that uses Big Data mining techniques to study the interaction of these decisions on the process's performance and the quality of the end product. This method uses stochastic optimization models to provide policies for the preferred suppliers and the settings for their process parameters.

2 - Machine Learning Methods for Revenue Prediction in Google Merchandise Store

Vahid Azizi, Graduate Research Assistant, Iowa State University, Ames, IA, 50010, United States, vazizi@iastate.edu, Guiping Hu

Machine learning has gained increasing interests from various application domains for its ability to understand data and make predictions. In this study, we apply machine learning techniques to predict revenue per customer for Google Merchandise Store. Exploratory data analysis (EDA) was conducted for the customer dataset and feature engineering was applied to find the best subset of features. Four machine learning methods including Gradient Boosting Machine (GBM), Extreme Gradient Boosting (XGBoost), Categorical Boosting (CatBoost), and Light Gradient Boosting Machine (LightGBM) and one ensembling method have been applied to predict revenue per customer.

3 - A Process Monitoring Framework for Supply Chain Management using MLCPM2

Mohammad Najjartabar Bisheh, Kansas State University, Manhattan, KS, United States, mnajjartabar@ksu.edu, Shing Chang

This research presents a process monitoring framework named MLCPM (Multi Layer Classifier Process Monitoring) to predict the likelihood of having safety problem comes from any raw material batch in a batch dispersion problem. This approach will help company to trace and call all finished or in process product which has problem before delivering to customers. Obviously recalling problematic material before delivering to customer will save a significant amount of budget and minimize amount of finished defect product while it tracks and find the reason fast because the more raw mixed materials in batches means the bigger recall, and higher cost.

4 - Optimization of Farm Management Strategies using Crop Models

Javad Ansarifar, Iowa State University, Ames, IA, 50010, United States, Faezeh Akhavizadegan, Lizhi Wang, Guiping Hu

Farm management strategies have both short-term and long-term consequences, economically, environmentally, and socially because of interactions of human, natural and material resources. Using crop models as promising tools for evaluating these strategies has two major challenges: 1. Parameters of models need manual calibration for every new dataset, 2. Because of complex structures, most crops models have been mainly used for prediction purposes and not for optimization. We address these challenges by training an explainable model to approximate the relationship between the performance of crop models and the parameters and optimize this model to identify optimal farm management strategies

WD03

CC- Room 203

Spatio-temporal Data Mining

Sponsored: Data Mining

Sponsored Session

Chair: Mustafa Gökçe Baydo an

1 - Spatiotemporal Missing Data Imputation for Photovoltaic Power Generation

Burak Tabak, Bogazici University, Istanbul, Turkey, burak.tabak@boun.edu.tr, Ismail Toyhan Yumru, Dilara Aykanat

Utility companies make use of automatic meter reading data to obtain production series of PV stations in their region. In order to be able to make reliable forecasts for their market operations, the continuity of the metering data should be flawless. Nevertheless, data transmission is frequently interrupted since the PV stations are generally located in rural areas. In this study, a tree-based method is proposed for the imputation of spatially distributed production time series of over a thousand stations with a total capacity of over 1 GWe, located in Turkey. The uncertainty introduced by the weather conditions are covered using the 0.25° Global Forecast System numerical weather predictions.

2 - Similarity-based Time Series Classification using Randomized Tree-based Transformation

Berk Gorgulu, University of Toronto, Toronto, ON, Canada, bgorgulu@mie.utoronto.ca, Mustafa Gokce Baydogan

Distance calculation between time series is a challenging task due to potential translation and dilations of patterns. Therefore, standard measures (L1, L2, etc.) fail to calculate distance properly. In this work, we utilize series of random trees to represent time series in terms of terminal node information. This new representation handles these potential problems successfully, allows using standard distance measures and provides competitive performance for 128 time series classification datasets from UCR Archive. Moreover, to deal with the sparsity of proposed representation, alternative feature selection approaches are evaluated without distracting the classification performance.

3 - Ntreeclus: A Model-based Partitioning Clustering of Sequential Data

Mustafa Gokce Baydogan, Bogazici University, Bogazici University, Department of Industrial Engineering, Istanbul, 34342, Turkey, Hadi Jahanshahi

Our study proposes a new Model-based approach for clustering sequence data, namely nTreeClus. The proposed approach is at the intersection of the conceptions behind existing approaches, including Decision Tree Learning, k-mers, and autoregressive models for categorical time series, culminating with a novel numerical representation of the categorical sequences. This new representation is used to perform clustering considering the inherent patterns in categorical time series. Furthermore, the only parameter of the method, the window size (n), is examined and the robustness of the method to its parameter has been shown.

WD04

CC- Room 204

Key Drivers of Hospital Performance in a Value-Based World

Sponsored: Data Mining

Sponsored Session

Chair: Kate Li

1 - Neighborhood Racial Segregation, Hospital Cancer Technology, and Racial Disparities in Cancer Outcomes: An Exploration

Nirup M. Menon, Professor, George Mason University, Fairfax, VA, 22030, United States, nmenon@gmu.edu, Cara Frankenfeld, Timothy Leslie

Black patients appear to suffer worse cancer outcomes than white patients. The role of the hospital and that of the cancer diagnosing and treating capabilities of the hospital in racial disparities has not been well-studied. This research explores the relationship between racial residential segregation and the availability of cancer technologies in hospitals. It explores the relationship between cancer technologies in a hospital, the race of the patient, and cancer outcomes (time to chemo, time to surgery, time to death) of the patient. The data consists of detailed patient-level data from the Georgia registry and the hospital-level data from AHA.

2 - The Impact of Health Information Technology on Hospital Staffing Decisions

Kate Li, Suffolk University, Boston, MA, 02108, United States, kjli@suffolk.edu, Mona Al-Amin

Healthcare Information technology (HIT) influences the clinical, operational and financial domains of performance in healthcare organizations. Previous research has focused mainly on the association between HIT and clinical outcomes, with limited research on the association between HIT and operational performance. In particular, literature on the impact of HIT on staffing decisions is scant and hospital managers lack evidence and guidance on staffing decisions with the implementation of HIT. In this study, we examine the impact of HIT on hospital staffing levels and mix of key medical staff, including different types of physicians and nurses.

3 - Continuity of Care and Risk of Readmission

Claire Senot, Tulane University, New Orleans, LA, 70118, United States

This study investigates the association between continuity of care mechanisms and a patient's risk of readmission in the context of one chronic condition, heart failure. Continuity of individual referring provider, continuity of physical location, and continuity of Accountable Care Organization are measured dynamically using patient-level claims. Results from a competitive-risks survival model reveals that all three continuity mechanisms are associated with a patient's lower risk of readmission.

4 - Predictive Analytics for Inpatient Readmissions

Hui Jia, University of Tennessee, Knoxville, UTK, Knoxville, TN, United States, Bogdan C. Bichescu, Haileab Hilafu

Recent Medicare initiatives linking reimbursements to readmission rates have placed renewed pressure on hospitals to reduce patient readmissions. We provide predictive analytics technique to predict inpatient readmissions with features related to physician, hospital and patient. Preliminary results indicate that our approach yields competitive performances compared to existing methods.

■ WD05

CC- Room 205

Big Data Analytics in Retail Operations and Service Industry

Sponsored: Data Mining

Sponsored Session

Chair: Amy Pan

1 - Optimal Display and Replenishment for Perishable Products Using Neural Reinforcement Learning

Xiajun Amy Pan, University of Florida, Gainesville, FL, 32611-7169, United States, amy.pan@warrington.ufl.edu, Fan Lu, Xiyao Ma, Xiaolin Li

We consider the problem of a retailer managing the inventory and display of perishable products in an infinite time horizon. We develop a neural reinforcement learning approach to effectively characterize the best ordering and display policies and discounting schemes for old products. We provide valuable guidance for practitioners.

2 - Dynamic Assortment Optimization in the Presence of Outlier Customers

Yining Wang, University of Florida, Gainesville, FL, 15213, United States, ynwang.yining@gmail.com

In this paper, we study the problem of dynamic assortment planning in the presence of outlier customers. In our setting, while most customers follow multinomial logit choice models, a fraction of the arriving customers will be “outliers” and might have arbitrary preferences of the items. We show how to handle such outlier customers by developing an “active elimination” type algorithm that sequentially remove items not preferred by non-outlier customers. Rigorous theoretical results are established to show the near-optimality of our proposed algorithm. An adaptive algorithm which does not require prior knowledge of outlier portions is also given.

3 - News Event-driven Predictive Models for Forecasting Socio-economic Indicators

Sunandan Chakraborty, Indiana University IUPUI, Indianapolis, IN, United States, sunandanchakraborty@gmail.com, Ashwin Venkataraman, Srikanth Jagabathula, Lakshminarayanan Subramanian

We present Event Class Model, a novel generative model of real-world events and employ it to extract events from a large corpus of news articles. We use the extracted events to generate time-stamped event embeddings and use them for predicting the fluctuations of socio-economic indicators. Then, we introduce the concept of Recurrent Event Networks (RENs), which makes use of a recurrent neural network (RNN) for predicting fluctuations in the socio-economic indicator of interest. We have trained RENs food prices and disease outbreaks and show that they can perform significantly better (up to 33%) than linear predictive models employing the same time-stamped event embeddings.

4 - A Deep MNI-bandit Approach for Personalized Food Recommendation with Social Networks

Na Zhang, University of Florida, Gainesville, FL, United States, Fan Lu, Xiajun Amy Pan

We develop a personalized food recommendation system for an on-demand service platform taking into account consumers’ locations, historical purchasing, and peer reviews of social networks. We formulate this problem as a Multinational Logit-Bandit model and propose an efficient deep bandit learning solution approach.

■ WD06

CC- Room 209

Limits of Large-Scale Statistical Learning

Sponsored: Data Mining

Sponsored Session

Chair: Shahin Shahrampour

1 - New Sample Complexities for Inference from underdetermined Models with Statistical Priors

Piya Pal, University of California, San Diego, La Jolla, CA, United States, pipal@eng.ucsd.edu, Ali Koochakzadeh

In recent years, the application of higher order statistics in identifying latent variable models has gained a great attention due to the powerful inherent expressivity of multilinear models. In this paper, we consider linear underdetermined models characterized by sparse parameters and show that in presence of certain priors on d-th order statistics, it is possible to reliably recover sparse supports of size O(M^d), where M denotes dimension of measurement vectors, with a probability of error approaching zero, exponentially fast as the number of independent measurement vectors increases.

2 - When Does Non-Orthogonal Tensor Decomposition Have No Spurious Local Minima?

Sina Baharlouei, University of Southern California, Los Angeles, CA

Tensor Decomposition approaches are demonstrated to be effective tools for modeling and solving a wide range of problems in the context of signal processing, statistical inference, and machine learning. In this talk, we analyze the optimization landscape of the d dimensional fourth-order Tensor decomposition problem with k non-orthogonal components. We show that under mild statistical assumptions, all local minima of this problem are global. To recover the decomposition components, we introduce the tensor power method (TPM) augmented by deflation and restarting.

3 - Parameter Tuning in High-Dimensional Problems

Arian Maleki, Columbia University

Please check the mobile app for this abstract.

4 - On the Dynamics of Gradient Descent for Autoencoders

Thanh Nguyen, Iowa State University, Ames, IA, United States

Why is gradient descent effective in machine learning? We ask this question in the context of unsupervised learning - specifically, learning weight-tied autoencoders - and provide two partial answers from the statistical learning standpoint: (1) a local result establishing the efficacy of gradient descent for reliable parameter estimation in the underparameterized setting, and (2) a global result which establishes conditions for gradient descent to converge optimally in the overparameterized setting.

■ WD07

CC- Room 210

Internet and Mobile Commerce Applications of Data Analytics

Sponsored: Data Mining

Sponsored Session

Chair: Abhijeet Ghoshal

Co-Chair: Dicle Yagmur Ozdemir, University of Texas, Richardson, TX

1 - Novelty in Online Reviews and Review Helpfulness

Dicle Yagmur Ozdemir, University of Texas-Dallas, Richardson, TX, United States, yagmur@utdallas.edu, Sumit Sarkar

User generated contents such as reviews and ratings are valuable for platforms. To better leverage such reviews, platforms enable users to vote on reviews such as their helpfulness. We are investigating the relationship between review novelty and helpfulness. We characterize novelty as information not mentioned in other reviews, and identify a suitable measure for our task. We evaluate reviews by the new information they provide and examine the impact on helpful votes received. A related question is whether the repetition of information helps or hurts the helpfulness of a review. Therefore, we also examine the effect of such reinforcement on the helpfulness of a review.

2 - Understanding Longitudinal Impact of Preference Biases on Recommender Systems' Performance

Meizi Zhou, University of Minnesota, Minneapolis, MN, United States, zhou0793@umn.edu, Gediminas Adomavicius, Jingjing Zhang

Prior research shows that online recommendations have significant influence on consumers' preference ratings and economic behavior. Biases induced by recommender systems' predictions can lead to distortions in users' self-reported preference ratings after consumption, which, in turn, contaminate the subsequent inputs to the system with inaccurate user preferences. In this work, we use an agent-based simulation approach to examine the longitudinal impact of users' preference biases on recommender system's performance under a variety of conditions. We also investigate multiple factors that influence recommender system's capability of correcting the system's performance over time.

3 - Predicting Alliances Using Prior Firm Relationships Using Machine Learning

Ramanath Subramanyam, University of Illinois, Champaign, IL, United States, rsubrama@illinois.edu, Carla Fernandez-Corrales

Predicting the potential alliance partner of a firm is a rigorous exercise with seemingly innumerable possibilities; yet, this is an activity strongly associated with outcomes such as firm performance and product innovation. In this paper, we present a heterogeneous network model that employs firm alliance data to predict a firm's alliance partner in the near horizon.

4 - Multi-Channel Attribution A Survive Analysis Based Approach

Jeffrey Jiang

Please check the mobile app for this abstract.

■ WD08

CC- Room 211

Artificial Intelligence III

Contributed Session

Chair: Xuying Zhao, University of Notre Dame, Notre Dame, IN, 46556, United States

1 - Black-box Data-driven Optimal Decisions via the Machine Transform

Evan Barlow, Weber State University, Ogden, UT, United States

Machine learning methods represent a significant advance in predictive analytics. Prediction is most fitting, however, when inputs and outputs are out of decision makers' control. Optimizing predicted objective functions over decision variable inputs is very difficult (if possible at all) for current machine learning tasks. The novel machine learning task presented here, called the Machine Transform, promises a scalable approach to black-box optimal decision making. The approach has successfully been applied to prescribe optimal decisions using several large-scale sandbox datasets.

2 - The Influence of Feature Scaling on the Stock Prediction

WenYi Lee, Shih Hsin University, Taipei, Taiwan, wylee@mail.shu.edu.tw

This study analyzes the forecasting performance of stock prices by applying two feature scaling methods, normalization and standardization, with comparing to non-scaling method, in machine learning. After transforming the feature boundaries into scales, the features reduce gradients to achieve an optimal solution more efficiently. The models applied include logistic regression, decision trees, and support vector machine. The results using the S&P 500 composite stock returns show the prediction performance and the timing to apply of various scaling methods.

3 - Optimal Predictive Clustering

Matthew Sobiesk, Massachusetts Institute of Technology, Cambridge, MA, United States, Dimitris Bertsimas, Yuchen Wang

The ability to make high quality predictions in an interpretable and scalable manner is a key problem in machine learning. In this work, we present a novel interpretable machine learning methodology called Optimal Predictive Clustering that uses integer optimization to cluster data followed by the training of cluster-specific regression models in order to make predictions. We report a comparison of our method with other interpretable machine learning models, such as optimal regression trees with hyperplanes, and show that our method exhibits comparable accuracy and significantly faster training times on large scale data without sacrificing interpretability.

4 - Comparison of Interpretability Between Optimal Trees and Popular Explainability Tools

Jeremy J. Toledano, Research Scientist, Interpretable AI, Cambridge, MA, United States, jeremy@interpretable.ai, Dimitris Bertsimas, Jack W. Dunn

Explainability tools like LIME and SHAP are often used to justify the choice of black-box machine learning models in fields where understanding how a model impacts decision-making is critical, e.g. finance. Let us explore how such tools compare to inherently interpretable machine learning algorithms like Optimal Trees.

5 - Machine Learning-based Pricing in Online Marketplaces

Xuying Zhao, University of Notre Dame, Notre Dame, IN, United States, xzhao1@nd.edu, Mike Chapple, Robert F. Easley, Hong Guo, Sriram somanchi

Merchants compete intensely for potential customers in online marketplaces such as Amazon. Setting the prices in such a highly dynamic, competitive environment is a challenging problem. In this paper, we build a machine learning-based demand prediction model and then derive the corresponding pricing strategy to improve sales.

■ WD09

CC- Room 212

Intelligent Information Retrieval in FinTech

Sponsored: Artificial Intelligence

Sponsored Session

Chair: Houping Xiao, Robinson College of Business/GSU, Atlanta, GA, 30303, United States

1 - Risk Disclosures and ST Prediction: A Machine Learning Approach

Hongwei Wang, Tongji University, Shanghai, China, Yuan Song

Publicly traded firms with abnormal financial status will be marked as "ST" (Special Treatment) by China Stock Exchanges since 1998. This study applies Latent Dirichlet Allocation model to analyze textual risk disclosures in annual reports, and examines their associations with firms' ST.

2 - A Study on the Effect of Financial Structure on Technological Innovation Performance – the Mediating Effect of Innovation Input

Siwei Huang, Huazhong University of Science and Technology, Wuhan, China, 1045568892@qq.com

By structural equation model, we find that: the innovation investment of the GEM (growth enterprise market) enterprises of China has been formed diversification of financing system, including endogenous (corporate cash flow, retained earnings) and external financing (equity financing, debt financing, government subsidy). Cash holdings have a smooth effect on innovation investment; Retained earnings, equity financing and debt financing improve innovation investment and performance of technological innovation;Government subsidies promote innovation investment, but corporate innovation performance was negative correlation with it. Innovation investment plays a mediating role.

3 - An Analysis of the Correlations Between Stock Prices of Chinese Listed Firms and Their Financial Information: An Empirical Study Based on the Information Industry

Danxia Guo, Associated Professor, Xiamen University, Xiamen, China, Sijia Cao

The associations between stock prices and financial information can be used to assess the development of the stock market in China and levels of rationality of its investors. Considering stock prices and relevant financial information as endogenous factors, this paper analyzes the extents of short-term dynamics and long-term equilibria of the interrelations between stock prices and financial information of firms in the information industry. Our study suggests that the information industry on the stock market in China is semi-strong efficient. Stock prices are partly capable of reflecting the state of operation in the past of the firms but limited in predicting the state in the future.

4 - The Influence of Managerial Ability on Corporate Innovation

Shaoqin Ye, Xiamen University, Xiamen, China, ysq@xmu.edu.cn

Based on the data of Chinese listed firms from 2007 to 2015, this paper investigates the impact of the heterogeneity of managerial ability on corporate innovation. We find that there is a significant negative correlation between managerial ability and corporate innovation. We further find that the nature of property right has a certain moderating effect on the relationship between managerial ability and corporate innovation.

5 - Can Information from Twitter Predict Economic Statistics?

Bing Anderson, Cal Poly State University, San Luis Obispo, CA, United States, bianders@calpoly.edu, Karen Freberg, Shuyun Li, Laura Freberg

If someone loses his job, he could easily be on Twitter talking about it that very same day. For that person to file an initial unemployment insurance claim, and for the initial claims statistics to be compiled and released, that process could easily take a lot more time. Hence, studying tweets on job losses could help one gain information about the upcoming initial jobless claims statistics release by the US Government. Studying the correlation between "lost"+"job" tweet counts and the non-seasonally-adjusted initial jobless claims, we found a statistically significant positive relationship between the two time series.

■ WD10

CC- Room 213

Creating Value with Social Media Analytics

Sponsored: Social Media Analytics

Sponsored Session

Chair: Gohar Khan, University of Waikato, Hamilton, 3240, New Zealand

1 - The Use of Social Media for Innovation: A Case Study of Twitter in B2B Marketing

Abhay K. Singh, Senior Lecturer, Macquarie University, Sydney, Australia, abhay.singh@mq.edu.au, Helen Cripps, Thomas Mejtoft

The objective of this explorative research is to enhance the understanding of the use of Twitter in business relationships. Structured interviews cross 5 countries found that the primary use of Twitter in business relationships was for quality information exchange and innovation. The study uses Structured topic modelling to investigate the type of topics discussed in a sample of Tweets posted by the interviewees. The terms generated are further used to identify possible topics around information exchange and innovation and their relative importance among the generated topics. The findings highlight the opportunities social media platforms provide for information exchange and innovation.

2 - Recent Results in Value with Social Media Analytics

Hangjung Zo, KAIST, Korea, Republic of

Recent results in social media analytics are explored.

3 - Digitally Enabled Strategic Transformation in Organisations

Carmen Leong, UNSW, Australia

Recent results in social media analytics are explored. The focus is on digital empowerment in social studies and digitally enabled strategic transformation in organisations.

4 - Recent Results in Value with Social Media Analytics

Shivendu Pratap Singh, Waikato University, New Zealand

Recent results in social media analytics are explored.

■ WD11

CC- Room 214

Learning and Control in Stochastic Systems

Sponsored: Applied Probability

Sponsored Session

Chair: Yuan Zhong, University of Chicago / Booth School of Business, Chicago, IL, 60637, United States

1 - Reinforcement Learning for Network Control

Qiaomin Xie, Cornell University, Ithaca, NY, 02139, United States, Bai Liu, Eytan Modiano

With the rapid growth of information technology, network systems have become increasingly complex. In particular, designing network control policies requires knowledge of underlying network dynamics, which are often unknown, and need to be learned. We propose to use model-based reinforcement learning. By applying Lyapunov analysis, our algorithm can be applied to queueing networks with unbounded state spaces. We prove that under our algorithm, the average queue backlog can get arbitrarily close to the optimal result. We also implement simulations to illustrate the effectiveness of our algorithm.

2 - Dynamically Protecting Privacy, under Uncertainty

Mine Su Erturk, Stanford Graduate School of Business, Stanford, CA, 94305, United States, Kuang Xu

We propose and analyze the -Noisy Goal Prediction Game, to study the fundamental privacy vs. efficiency tradeoff in dynamic decision-making problems with non-trivial uncertainty. An agent is trying to quickly reach a final goal in a network, through a sequence of intermediate actions, while the effects of her actions are subject to random noise and perturbation. Meanwhile, an overseeing adversary, who observes the effects of the agent's past actions, is trying to predict the goal before the agent reaches it. We are interested in understanding the probability that the adversary predicts the goal correctly (prediction risk) as a function of the time it takes the agent to reach her goal (delay).

3 - Collaboratively Learning the Best Option on Graphs, Using Bounded Local Memory

Lili Su, Massachusetts Institute of Technology, 459 Coordinated Science Lab MC 228, 1308 W. Main St., Cambridge, MA, 61801, United States, lilisu@mit.edu, Martin Zubeldia, Nancy Lynch

We consider multi-armed bandit problems in social groups wherein each individual has bounded memory. We say an individual learns the best option if eventually it pulls only the arm with the highest expected reward. While provably impossible for an isolated individual, we show that, in social groups, this goal can be achieved easily with the aid of social persuasion under mild network conditions. To deal with the interplay between the randomness in the rewards and in the social interaction, we employ the mean-field approximation method. Since the individuals in the networks may not be exchangeable, we go beyond the classic mean-field techniques and apply a refined version of mean-field approximation.

4 - Beating the Curse of Dimensionality in Optimal Stopping

Yilun Chen, Cornell ORIE, 292 Rhodes Hall, Ithaca, NY, 14853, United States, yc2436@cornell.edu, David Goldberg

High-dimensional optimal stopping arises in various practical settings and is notoriously challenging due to the curse of dimensionality. Typical modern approaches (ADP, simulation, duality) either scale poorly, or have limited performance guarantees. We overcome this computational obstacle by proposing the first algorithm that can trade-off between accuracy and runtime(analogous to a PTAS). Our algorithm outputs an epsilon-approximation with runtime and sample complexity both polynomial in time horizon T (effectively independent of the dimension) for any fixed epsilon. Time permitting, we also discuss several faster/more practical algorithms built on the same framework.

■ WD12

CC- Room 2A

Optimization and Approximations for Queues

Sponsored: Applied Probability

Sponsored Session

Chair: Mariana Olvera-Cravioto, University of North Carolina-Chapel Hill, Chapel Hill, NC, 27599, United States

1 - High-order Lindley Equations in Write-only Systems

Mariana Olvera-Cravioto, University of North Carolina-Chapel Hill, Chapel Hill, NC, 27599, United States, molvera@email.unc.edu

We study a model for read-only database systems where users request simultaneous writing access to a random number of files. While files are being used, no other users can access them, creating blocking and idleness. We focus on the stationary waiting time of customers prior to receiving access to their requested files, and characterize its tail distribution. Moreover, when the access-time is allowed to depend on the number of files being requested, the waiting time is seen to satisfy a new type of high-order Lindley equation.

2 - Online Optimal Pricing and Capacity Sizing for G/ G/ 1 Queue with Demand Learning

Yunan Liu, North Carolina State University, Raleigh, NC, 27695-7906, United States, yliu48@ncsu.edu, Xinyun Chen

We consider a pricing and capacity sizing problem in a G/G/1 queue with an unknown demand curve. The service provider's objective is to adaptively adjust the service price p and service rate μ so as to maximize cumulative expected revenues (the service revenue minus the delay penalty) over a given finite time horizon; in doing so, the service provider needs to resolve the tension between learning the unknown demand curve (p) and maximizing earned revenues. We develop an adaptive algorithm based on stochastic gradient descent and provide asymptotic bounds for the regret. We also discuss possible accelerating methods for the algorithm.

3 - When Does Collaboration Help?

Rhonda Righter, UC Berkeley, Berkeley, CA, United States, rrighter@berkeley.edu, Kristen Gardner

We consider a Markov skill-based queueing system with heterogeneous jobs and servers, where the job class determines the subset of servers that can serve that job. In the collaborative model, the same job can be served by multiple compatible servers, with service rate that is the sum of the individual servers' service rates. In the more standard, noncollaborative, queueing model, at most one server can work on each job. In general, collaboration helps in symmetric systems, but may not in asymmetric systems.

4 - Resource Sharing Networks and Brownian Control: A Lower Bound on Asymptotic Cost

Michael Conroy, University of North Carolina-Chapel Hill, Chapel Hill, NC, United States, mconroy@live.unc.edu

A family of resource sharing networks proposed as models for internet flows is considered. Under heavy traffic, the asymptotic cost of this system can be approximated by a Brownian control problem (BCP), which is an optimization problem in terms of a Brownian motion on some space. For both a discounted cost and ergodic cost criterion, an appropriate BCP gives a lower bound on the best achievable asymptotic cost under any sequence of admissible policies. These lower bounds show that certain control policies constructed in previous work are, in fact, optimal. This talk is based on joint work with Amarjit Budhiraja.

5 - Ergodic Control of Diffusions with Compound Poisson Jumps under a General Structural Condition

Guodong Pang, Penn State University, Industrial and Manufacturing Engineering, University Park, PA, 16802, United States, Yi Zheng, Ari Arapostathis

We study the ergodic control problem for a class of controlled jump diffusions driven by a compound Poisson process. The formulation of the problem arises from queueing networks in the Halfin-Whitt regime, which motivates the new methodology framework with a general structural assumption. We derive the HJB equations and provide the characterization of optimality and the regularity properties of the optimal solutions. We establish the epsilon-optimality for the controlled jump diffusions by using the spatial truncation method. The results with the pathwise optimality is also discussed.

■ WD13

CC- Room 2B

Decision Analysis III

Contributed Session

Chair: Suhao Chen, Oklahoma State University

1 - Ordinal One Switch Independence in Multi Attribute Utility

Shuoli Liu, Harvard University, Cambridge, MA, United States

We introduce a Rn generalization of ordinal one-switch independence (Abbas&Bell, 2015). Both necessary and sufficient conditions are presented for this ordinal property. We further characterize Homothetic Utility and partially separable utility with these new conditions.

2 - Calibrating a Group Utility Function That Minimizes Interview-data Requirements

Yupo Chan, University of Arkansas, Little Rock, AR, United States, ychan@alum.mit.edu, Raymond Staats, Oluwamuyiwa Adeegbe

We use multi-attribute utility-theory to define a mathematical representation of a decision-maker's utility. By eliminating the use of lottery questions, the survey is simpler to administer. The calibrated utility-function is then used in a multicriteria-optimization model for scheduling purposes. A case study is conducted in which two different decision-makers' preferences are combined to characterize a group utility-function. Again, a simple procedure is proposed to arrive at a group utility-function.

3 - Uncertainty Characterization Using Quantile-parameterized Distributions and Belief Functions: A Practitioner'S Perspective

Neil Hamlett, Education Data Scientist, IBM, Vienna, VA, United States, neil.hamlett@uncertainty-research.science, Patrick Leach

We explore the practical application of Theory of Evidence (ToE) to framed decision analysis. The dominant paradigm for decision framing follows a methodology first described separately by Howard [Howard2016] and Raiffa [Raiffa1970]. A decision tree represents decisions, framed as alternative scenarios. Scenario-outcome probabilities from the decision tree are represented using "metalog" distributions [Keelin2016], which are mixtures of distinct event distributions. We employ Keelin's framework to unwind the mixtures. We employ statistical characterizations to compare ToE-based and "traditional" uncertainties.

4 - Power Index of Nodes in Interdependent Networks: Coalitional Game Theory Approach

Katherine E. Barnett, University of Oklahoma, Norman, OK, United States, kathebarnett@ou.edu, Shima Mohebbi

During and after a disruptive event, interdependent infrastructure sectors complete or partially cooperate to allocate limited resources such as time, repair crews, and money to restore the networks. We will formulate a cooperative game model to measure the power and contribution of nodes in interdependent networks. We will propose a utility function that considers node precedence and infrastructure interdependencies. The results will assist utilities in allocating limited resources in a shared interdependent network.

5 - A Design Loop for Managing Many-goal Problems

Suhao Chen, Oklahoma State University, Stillwater, OK, United States, suhao.chen@okstate.edu, Lin Guo, Jelena Milisavljevic-Syed, Janet Katherine Allen, Farrokh Mistree

Multi-goal problems have been well studied. There are decision-support methods working effectively for two-goal and three-goal problems, however, as the number of goals increases, the accuracy and computational efficiency of those methods diminish. A method that particularly works for many-goal problems is required. We propose the Formulation-Approximation-Exploration method, to deal with the many-goal problems in five modules - model formulation, generation, clustering, converting, and exploration. A test problem in multi-criteria engineering design is used to verify the utility of the method.

■ WD14

CC- Room 302

Joint Session MSOM/Practice Curated: Operations of Innovative Retail Models

Sponsored: Manufacturing & Service Oper. Mgmt

Sponsored Session

Chair: Robert Swinney, Duke University, Durham, NC, 27708, United States

1 - What is in the Subscription Box: Managing Content to Acquire and Retain Subscribers

Soudipta Chakraborty, Duke University, NC, 27708, United States, sc390@duke.edu, Fernando Bernstein, Robert Swinney

We consider a model of a subscription service like Blue Apron or Birchbox that ships boxes of physical products to subscribers at regular intervals for a fixed, pre-determined, per-box price. While subscribers know their preference for a product, they learn their utility from using the service only after subscribing. We study how the service provider should allocate her total budget for content to boxes over a planning horizon to maximize total demand from new and existing subscribers.

2 - Pick-up, Delivery, or Both? An Online Grocer's Optimal Fulfillment Model

Chloe Kim Glaeser, University of North Carolina, Kenan-Flagler Business School, Chapel Hill, NC, 27514, United States, chloe_glaeser@kenan-flagler.unc.edu, Kenneth Moon, Xuanming Su

We partner with an online grocery retailer to answer the practice-based question of the optimal mix of delivery zones and fulfillment options using data-driven analytics. Based on this empirical evidence, we build and estimate a structural model and perform a counter-factual analysis to estimate the revenue increase from additionally offering delivery. We examine how the retailer can leverage data to customize locally available fulfillment options while scaling operations.

3 - Inventory Management for Exclusive Products

Ruslan Momot, HEC Paris, 1 Rue de la Liberation, Jouy-en-Josas, 78350, France, Elena Belavina

Firms selling conspicuous goods face a trade-off: producing more today allows for extracting more revenues but compromises the product's future reputation for exclusivity. We capture this trade-off in a dynamic model of strategic customer and firm behavior. We find that firms should optimally follow stationary cyclic strategies alternating scarcity and overproduction stages. The former builds reputation for exclusivity whereas the latter exploits it.

4 - Revenue Sharing and Subscription Platforms for Digital Content Distribution

Robert Swinney, Duke University, 100 Fuqua Drive, Box 90120, Durham, NC, 27708, United States, robert.swinney@duke.edu, Zhenhuan Lei

We analyze subscription services for digital information goods like books and music. Two content creators (low and high quality) choose whether to sell through the same subscription platform and are paid proportional to the percentage of total "use" that they generate on the subscription service. We show that with such a linear revenue splitting rule (commonly seen in practice), inducing the high quality creator to list on the subscription service is excessively costly, and typically not viable for the platform, which leads to low quality content on the service. We discuss remedies to this problem in the form of non-linear allocation rules to split revenue between content creators.

■ WD15

CC- Room 303

Research & Decision Support Systems

Contributed Session

Chair: Yasser Davizon, University of Texas-El Paso, El Paso, TX, 79968, United States

1 - Managerial Incentives and Research and Development Investment: The Moderating Role of Institutional Ownership and Product Market Competition

Furong Qian, University of Science and Technology of China, Hefei, China, Jin Hong

Studies have rarely discussed that the effect of managerial incentive on corporate R&D investment through external governance. This study examines the effect of managerial incentives on corporate R&D investment and how external factors affect this relationship. Based on panel data of 881 Chinese listed firms, our results reveal several interesting findings. Top managers' compensation with a degree of convexity promote corporate R&D investment. Further, institutional ownership and product market competition have significant moderating roles on this relationship. Additionally, when institutional ownership is higher, we indirectly verify agency problem with limited competence.

2 - Using Network Science Approach to Investigate Additive Manufacturing Readiness and Adoptiveness

Junfeng Ma, Assistant Professor, Mississippi State University, Mississippi State, MS, United States, ma@ise.msstate.edu

Additive Manufacturing is a fast growing manufacturing technology, however, the readiness and adoptiveness of this technology is still open question. This research utilizes a network science-based approach to investigate when and how additive manufacturing should be adopted, aiming to provide adequate recommendations to the potential clients of additive manufacturing and support their adoption decision making.

3 - Removing Barriers to Deploying Models to Business Users for Faster ROI

Libin Koshy Varghese, Principal Consultant, FICO, Secaucus, NJ, United States

Companies that have invested in predictive and prescriptive analytics are still experiencing high failure rates in deploying analytics that generate a positive ROI. Why build models if they never reach their intended users or aren't the right fit? In this talk, we will discuss some of the barriers data science and OR teams face when trying to put their analytics into action. We will also cover how a collaborative approach with the right tools can help teams avoid wasted effort, while delivering advanced analytics applications to end-users at higher quality than traditional methods.

4 - A Graphical Approach to Topic Modelling and Text Summarization

Neeraj Gadkari, Columbia University, New York, NY, United States, neeraj.gadkari@columbia.edu, Hardeep Johar, Aries Li

Topic based approaches to document summarization use word frequencies, LSA, etc., to identify topics and keywords in a document as a precursor to generating a summary. In this paper we present a methodology that uses knowledge graphs and graph properties to identify topics and generate document summaries. We use POS tagging and named entity analysis to construct a knowledge graph for a document, apply measures of centrality to identify topics represented by entities and their relationships, and use these centrality based topics to generate document summaries clustered around topic headings.

5 - Evaluation of the Efficacy of National Quality Infrastructure in China

Shiying Ni, Tsinghua University, Beijing, China, nisy13@163.com

National Quality infrastructure (NQI) is the ecosystem of institutions and regulations which establish and implement standardization, accreditation, metrology and conformity assessment. China has been developing NQI for decades to promote commodity quality. However, there is a lack of literature studying the efficacy of NQI. This paper will compensate this blank to provide evaluation of NQI efficacy and thus to give suggestions to NQI developing.

6 - Modeling, Analysis and Optimal Control for a Class of Production-decoupling Inventory System

Yasser Davizon, University of Texas at El Paso, El Paso, TX, United States, yadavizonca@miners.utep.edu, Heidi Taboada, Jose F. Espiritu

This research work presents a mathematical modeling and optimal control for a production-decoupling inventory system (PDI). A set of coupled ordinary differential equations represents the proposed PDI, which approximates the dynamic behavior of a factory. An optimal control analysis considers the minimum energy and time optimal control problems. Lyapunov stability and sensitivity analysis are present in PDI.

■ WD16

CC- Room 304

Empirical Research on Workforce Management

Sponsored: Manufacturing & Service Oper. Mgmt/Service Operations

Sponsored Session

Chair: Yong-Pin Zhou, University of Washington-Seattle, Seattle, WA, 98195-3226, United States

Chair: Qiuping Yu, Kelley School of Business, Indiana University, Kelley School of Business, Indiana University, Bloomington, IN, 47405-1701, United States

1 - Impact of Task-level Worker Specialization, Workload, and Product Personalization on Consumer Returns

Hailong Cui, University of Southern California, Marshall School of Business, Data Sciences and Operations, Los Angeles, CA, 90089-0809, United States, HailongC@marshall.usc.edu, Sampath Rajagopalan, Amy R. Ward

We study the impact of key operational levers on return rates, while controlling for numerous factors. We find that increased task specialization helps reduce return rates, but the impact is U-shaped. Increased workload levels in production result in higher return rates, whereas product personalization leads to lower return rates.

2 - Help or Hindrance? The Role of Familiarity in Collaborative Product Development

Necati Tereyagoglu, University of South Carolina, Scheller College of Business, 800 West Peachtree Street NW, Columbia, SC, 30308, United States, necati.tereyagoglu@moore.sc.edu, Karthik Ramachandran, Murat Unal

We empirically study product development in the video game industry by coupling a granular database of development credits with sales data. We find that familiarity in the team is associated with a decrease in sales. Separating this effect into different roles shows that familiarity between designers has a negative influence, while familiarity between producers has a positive influence on sales. We find that the positive influence by familiarity across producers is dominated due to an additional negative influence by the hierarchical familiarity between producers and designers. We further study how the effects can vary based on the nature of the experiences and the current role of the team members.

3 - Labor Planning in Retail Stores Using Customer Traffic Data

Marcelo Olivares, Associate Professor, Universidad de Chile, Santiago, Chile, molivares@uchile.cl

This work combines empirical analysis of point-of-sales data, customer traffic and employee staffing, with optimization methods to build a decision support tool that can be used by managers to plan labor allocation and working schedules, balancing gross margins, labor costs and employee satisfaction. An econometric model is developed to estimate the effect of labor on sales in an hourly basis, decomposing the effect of labor into conversion and ticket value. The empirical results are used in mathematical program that seeks to find the best feasible schedule to maximize store profitability, accounting for labor regulation restrictions and practical constraints.

■ WD18

CC- Room 306

Supply Chain Platforms

Sponsored: Manufacturing & Service Oper. Mgmt/Supply Chain

Sponsored Session

Chair: Milind Sohoni, Indian School of Business, Indian School of Business, Hyderabad, 500032, India

1 - Robust Optimal Recommendations for Risk-aware Customers

Yam Huo Ow, Northwestern University, Evanston, IL, United States, yamhuo.ow@kellogg.northwestern.edu, Chaithanya Bandi

We consider optimal recommendations problem for risk-aware customers with possibly uncertain risk preferences, where an online insurance platform has to offer the best insurance plan that matches the customers' risk preferences. We present a novel approach to model the uncertainty in risk preferences using robust optimization; and discuss tractable approaches for passive estimation and active learning to construct the uncertainty set of risk preferences from historical and interaction data, respectively. Lastly, we examine Linear Programming formulations which allow for tractable optimization with insightful solutions.

2 - Two-sided Assortment Optimization

Asrar Ahmed, Indian School of Business, Hyderabad, India, asrar_ahmed@isb.edu, Milind Sohoni, Chaithanya Bandi

We consider the problem of online service platforms which match job applicants with potential employers. Unlike traditional formulations which treat the participants as passive, we allow both employers and job applicants to exercise their choice. We introduce a two -sided assortment optimization model that captures the platforms constraint that it can only provide recommendations to each participant. We present a mixed-integer linear programming formulation of the model and provide performance bounds for a greedy online algorithm that can be solved efficiently. The algorithms are evaluated on real-world data set from a leading freelancing platform.

3 - Supplier Encroachment in a Non-Exclusive Reselling Environment

Parshuram Hotkar, University of Texas-Austin, McCombs School of Business, Austin, TX, 78712-1277, United States, Stephen Gilbert

We consider a setting in which a non-exclusive reseller procures partially substitutable products from two suppliers, one of whom introduces a direct-channel. We find that the presence of the second supplier alters many of the existing results about the interactions between a reseller and an encroaching supplier. For instance, the encroaching supplier may either sell exclusively through its direct-channel even when that channel is less efficient than the reselling-channel or sell through both channels even when its direct channel is more efficient than the reselling channel when the reseller is non-exclusive.

■ WD19

CC- Room 307

Procurement and Purchasing Management

Contributed Session

Chair: Hua Jin, University of Southampton, Southampton, SO17 1BJ, United Kingdom

1 - How the Risk Averse Buyers Choose the Marketing Strategy for New to Be Released Products

Xinran Shen, College of Management and Economics, Tianjin, China, xrshen@tju.edu.cn

The upgrading speed of products increasingly fast in the fierce competing niche market, many risk-averse companies adopt the advance selling strategy to deal with uncertain market when releasing the new product. We consider the risk averse behavior and experienced customer, aiming to explore the impact of the above two factors on how to develop the strategy (AS) and the decisions of company. We find that company's risk aversion leads to the decrease of the sales volume, but the increase of the company's utility. AS strategy is beneficial to the company, AS strategy with high discount is better than the low discount, it can also eliminate the demand uncertainty, thus offsetting the impact of risk aversion.

2 - The Effect of Information Policies in Procurement Negotiation: An Experimental Study

Junlin Chen, Central University of Finance and Economics, Beijing, China, chenjunlin@cufe.edu.cn, Cheng Qian

We consider a procurement negotiation between a buyer and a supplier, in which the buyer has private information about how to evaluate the suppliers' endogenous and exogenous qualities. Two types of information policies are examined. We establish two behavioral models characterizing the supplier's risk preference and judgment bias, respectively, and test the models using an experiment. We show that under EN policy, the suppliers are risk-loving and over-estimating; in contrast, under EX policy, the suppliers are risk-averse and under-estimating. The implications of our results for procurement negotiations are discussed.

3 - Developing Ensemble Predictive Models for Smart Procurement

Ramkumar Harikrishnakumar, Supply chain research analyst, Wichita state university, Wichita, KS, United States, rxharikrishnakumar@shockers.wichita.edu, Krishna Krishnan, Saideep Nannapaneni

In the era of industrial internet of things (IIOT, Industry 4.0), integration of information technology and acceleration of competitiveness are necessary for an effective supply chain management (SCM). Due to uncertain customer preferences, and fluctuating market demands, procurement plays a significant role in accomplishing the strategic goals of an organization. We develop a two-stage supplier selection framework by combining ensemble data-driven learning and probabilistic risk assessment.

4 - Information Seeking Biases in Supplier Selection

Somaye Ramezanpour Nargesi, University of Texas at Arlington, Arlington, TX, United States, somaye.ramezanpournargesi@mavs.uta.edu, Kay-Yut Chen

In this project we used a discrete choice setting to study information seeking behavior of procurement managers. Supplier selection has been studied from different aspects, most of which are prescriptive studies. We took a behavioral perspective to conduct a descriptive study of information seeking biases such as willingness to overpay for information, misjudgment of value of information,and pursuing irrelevant information in supplier selection context.

5 - Dynamic Procurement Strategy with Correlated Yields

Yi Li, Xi'an Jiaotong University, Xi'an, China, yili92-c@my.cityu.edu.hk, Lina Bao, Yimin Yu, Wei Zhang

We study a dynamic sourcing problem for a firm that faces unreliable suppliers, whose yields are correlated. The yield is specified by a supply function. Unsatisfied demand is fully backlogged. Our objective is to minimize the expected cost over a finite horizon. We introduce the notion of multi-dimensional upper-set monotonicity and establish a new preservation property of the monotonicity. Then we provide sufficient conditions to ensure the optimality of a threshold policy for the firm's order decision, which are applicable to a class of supply functions. Finally, we find that the optimal set of suppliers with positive orders is weakly consecutive in the minimum effective cost rates.

6 - A Methodology for Constructing Inventory Management Models Accounting for Taxation Schemes: the Case of the Dynamic Lot Sizing Problem

Hua Jin, University of Southampton, Southampton, United Kingdom, hj1g08@soton.ac.uk, Patrick Beullens

The OR literature in the area of logistics pays scant attention to cash flows that arise in order for the firm to fulfil its legal obligations. This research develops a methodology for constructing models for inventory management that explicitly account for UK taxation schemes. In this paper we focus on the case of the dynamic lot sizing problem. A fairly robust insight is that optimal ordering decisions often become synchronised with the value added tax/corporation tax return points within a standard tax scheme, while the benefit of considering taxes explicitly into the decision models increases the higher the product value and/or the lower the marginal profit on a product.

■ WD20

CC- Room 308

Service Science and Decision Analysis

Contributed Session

Chair: Takashi Irohara, Sophia University, 7-1 Kioi-cho, Chiyoda-ku, Tokyo, 102-8554, Japan

1 - Service Science

Diwas S. KC, Emory University, Atlanta, GA, United States

Please check the mobile app for this abstract.

2 - Service Order Allocation under Uncertain Demand: Risk Aversion, Peer Competition and Relationship Strength

Di Wang, Tianjin University, Tianjin, China, wd0410tju@126.com, Weihua Liu

This paper discusses the order allocation in service supply chains under uncertain demand, and builds a Stakelberg game model composed of a service integrator (SI), a key service supplier (SP), and an ordinary SP. There are three influencing factors: risk aversion, peer competition, and relationship strength. It was found that there is an offset effect between risk aversion and relationship strength and an amplification effect between peer competition and relationship strength. Only if three factors meet the equilibrium effect, can SI achieve higher expected utility. The "incentive upgrade and cost sharing" contract is proposed to improve SI's optimal expected utility.

3 - Green Product Design with Competition and Fairness Concerns

Tianqin Shi, San Jose State University, San Jose, CA, United States, Qingying Li, Xiaotong Guan

We consider a supply chain consisting of one manufacturer and two retailers, with one retailer having a distributional fairness concern. By investigating the impact of the retailer's distributional fairness concern on supply chain performance, we find that, for marginal-intensive green products, the manufacturer will lower the wholesale price but retain the green level; but for development-intensive green products, the manufacturer will lower both the wholesale price and the green level. For both types of products, the retailer with fairness concern will earn a smaller market share than its opponent. If an inequity outcome is unattained, the supply chain always performs worse.

4 - Optimal Container Selection in a Conflicting Objective Environment

Avnish Kishor Malde, Graduate Research Assistant, Clemson University, Clemson, SC, United States, Tugce Isik, Carrie Cline

We consider a warehouse with multi-product inventory, where the parts are continuously consumed based on the line-side demand. The inventory level is replenished using the available trailers and sea-containers. The sea-containers and trailers arrive overtime and we incur penalty on daily basis for holding them. We study the problem of optimally selecting the sea-container and trailers so as to reduce the number of remnant parts in the warehouse along with minimizing the detention penalties of the sea-containers and trailers. We model this problem using the Multi-Objective Mixed Integer Programming and solve it by using Goal Programming and -constraint method and present the numerical results.

5 - Optimal Storage Assignment for Order Picking in the Automotive Parts Warehouse with Multi-level Racks

Takashi Irohara, Professor, Sophia University, Tokyo, Japan, irohara@sophia.ac.jp

In this research, storage assignment for order picking are considered. Multi-level racks are used in the target warehouse holding automotive parts which are relatively large and heavy. In this reason, picking time at each level of rack is different and higher position needs longer time for picking. But no usage of higher level of rack takes wider space for storage assignment and incurs longer walking time for the order picking. Then we propose a three-dimensional storage assignment model to optimize the order picking and formulate it as a mixed integer programming problem. In order to demonstrate the effectiveness of the proposed model, numerical experiments using actual data are conducted.

■ WD21

CC- Room 309

Forecasting IV

Contributed Session

Chair: Courtney Burris, University at Buffalo, Buffalo, NY, 14216, United States

1 - Marketing-Operations Interface

Jeffrey Shulman, University of Washington, Seattle, WA, United States, jshulman@uw.edu

Please check the mobile app for this abstract.

2 - Incorporating Climate Modeling into Dengue Outbreak Predictions

Ying Zhang, Johns Hopkins University, Baltimore, MD, United States, ying.zhang@jhu.edu, Ensheng Dong, Sauleh Ahmad Siddiqui, Lauren Gardner

Dengue, a mosquito-borne viral disease, poses a serious global burden. Accurate prediction of dengue outbreaks can help effectively conduct disease surveillance and vector control. We proposed a model that incorporates the state-of-the-art real-time climate seasonal forecast from the North American Multi Model Ensemble (NMME) along with other known dengue risk factors into an outbreak prediction framework, and apply it to the dengue-prone region of Negombo, Sri Lanka. A sensitivity analysis is performed to evaluate how reliability of NMME climate predictions affects dengue predictions.

3 - Network Effects in Influenza Spread: The Impact of Mobility and Socio-economic Factors

Courtney Burris, University at Buffalo, Buffalo, NY, United States, cburris2@buffalo.edu, Alexander Nikolaev, Ling Bian, Shiran Zhong

This project reveals and quantifies the patterns in the spread of influenza over a region within a big city, as a function of population mobility. With census block groups taken as units of study and travel frequency as weighted connections between the units, a weighted attributed network is constructed and analyzed using social network analysis techniques. A new approach is presented to conduct hypothesis testing, regression, and surprise-based analyses on such networks.

■ WD22

CC- Room 310

Supply Chain, Managing Disruptions

Contributed Session

Chair: Hasmukh Gajjar, Associate Professor, Indian Institute of Management Indore, Rau-Pithampur Road, C#208, Prabandh Shikhar, Indore - Madhya Pradesh, 453331, India

1 - Effect of Salience of Available and Relevant Information About a Supply Disruption Trigger and Occurrence on Severity of Impending Supply Disruption

Rahul Pandey, The Ohio State University, Columbus, OH, United States, pandey.79@osu.edu, Hyunwoo Park, Manus Rungtusanatham

We examine how early supply disruption warning information availability (signal earliness) and warning information fluctuation (signal oscillation) about a supply disruption trigger (hurricanes) and supply disruption occurrence influence severity of impending supply disruption (flight delays and cancellations). We also explore the moderation effect of variability in the source of warning signal (signal source variability).

2 - Competitive Contract Design for a Backup Supplier under Demand Uncertainty and Supply Disruption Risk

Ashutosh Sarkar, Associate Professor, Indian Institute of Management-Kozhikode, Kozhikode, India, asarkar@iimk.ac.in, Stefan Minner

We analyse the use of an options contract for the backup supply for a manufacturer who faces disruption risk for its supply from the main supplier. The relationship is modeled as a Stackelberg game and the analysis focuses on the manufacturer's trade-off between 'responsiveness and costs', and 'supplier opportunism and incentives.' The analysis reveals that demand and supply uncertainty prompt the manufacturer to utilize more of its backup options while the backup supplier exploits it with a price increase. Further, we also observed that the backup supplier incentivises the manufacturer with a lower options buy price when the lost sales penalty is lower.

3 - Inland Waterway Disruption Response under Uncertain Conditions

Jingjing Tong, Southeast Missouri State University, Cape Girardeau, MO, United States, jtong@semo.edu, Heather Nachtmann

The U.S. inland maritime system is a commercially and strategically important transportation mode. Unexpected disruptions can cause non-navigable water levels or destroy major navigation infrastructures, resulting in inland waterway closures and consequent economic and societal impacts. We developed an optimization approach to the cargo prioritization and terminal allocation problem (CPTAP) to minimize the total value loss of cargo disruptions. We are currently developing an enhanced CPTAP model to improve pre-event disruption response by assessing the resiliency of the inland waterway transportation system to handle disrupted cargo under uncertain conditions.

4 - Intermediation in the Supply of Agricultural Products in Developing Economies

Ehsan Valavi, Harvard Business School, Boston, MA, United States, evalavi@hbs.edu, Kris Johnson Ferreira, Joel Goh

The agricultural industry has been growing in developing economies, yet farmers continue to struggle. Recently, e-intermediaries (fixed-price channels who use technology) have emerged as an alternative channel to the traditional local auctions for which farmers can sell their crop. We study the impact that e-intermediaries have on the supply chain.

5 - Assortment Optimization for Retailers with Two Sales Channel Considering Customer Behavior

Cheng Zhenxia, Shanghai Jiao Tong University, Shanghai, China

Recently, retailers are able to sell products through two channels, say online and offline (physical store). In this case, there are three types of customers who prefer to shop online, to shop offline and to experience offline but buy online respectively. So it is critical for retailers to decide how to assort the products through the two channels. We aim to maximize the total profit of retailers.

6 - Inventory Planning for Retailers Using Realtime Consumption Data

Hasmukh Gajjar, Associate Professor, Indian Institute of Management Indore, Indore, India, hasmukh@iimidr.ac.in, Bhavin J. Shah

IoT devices have made possible for retailers to track the real-time consumption of items done by their consumers. It provides early signal to retailers to make their inventory planning better. Using simulation approach, this paper attempts to showcase the usefulness of real-time tracking of consumption data in inventory planning.

■ WD24

CC- Room 3B

Joint Session DAS/HAS: Decision Analytics and Economics of Information in Healthcare

Sponsored: Decision Analysis

Sponsored Session

Chair: Yeongin Kim, Virginia Commonwealth University, Glen Allen, VA, 23059, United States

Co-Chair: Mehmet U.S. Ayvaci, University of Texas at Dallas, Richardson, TX, United States

1 - Augmenting Radiologists' Decision Making Based on Mammography Using Deep Learning

Mehmet Eren Ahsen, University of Illinois, Champaign, IL, United States, Mehmet Ayvaci

Despite their increasing ubiquity, we are yet to understand when and how machine learning algorithms best augment human intelligence. Motivated by the complementarities between machine learning methods and human intelligence in solving prediction problems of heterogeneous difficulty, we propose an algorithm that optimally combines algorithmic predictions with expert judgments. We apply our algorithm on an imaging and radiologist assessments database that was used in a crowdsourced deep learning challenge for risk stratification of screening mammograms. We structurally and empirically characterize when and how radiologists' diagnostic decision making is enhanced.

2 - Drivers of Referral Networks: How Does Health Information Exchanges Impact Physicians' Decisions?

Saeede Eftekhari, State University of New York-Buffalo, Buffalo, NY, 14228, United States, Niam Yaraghi, Ram Gopal, Ram Ramesh

This study focuses on identifying the factors impacting the primary care physicians' referral decision making processes. After the clinical need for a referral has been recognized by a primary care physician, the referral could be modeled as the outcome of a two-stage decision process: During the first stage, the physician considers a set of potential specialists for the referral. During the second stage, the physician determines the volume of the patients to be referred to each specialist in the identified set. Our findings show that similarity with regards to participation in HIE has an impact on the primary care physicians' decisions during the first stage, and thus their consideration set.

3 - Health Information Exchanges' Pricing Strategies in a Competitive Environment

Yonghua Ji, University of Alberta, Business School, University of Alberta, Edmonton, AB, T6G 2R6, Canada, yji@ualberta.ca, Can Sun, Subodha Kumar

We study a setting two health information exchanges (HIEs) compete for healthcare provides (HP) to join its platform. The utility for an HP is determined by the intrinsic value offered by an HIE and the network effect. We use a game theoretical model to investigate how HIEs should price the basic and value-added services to maximize their profits. We also study how parameters affect the basic service price and value-added service price.

4 - Physician Decision-making Process in Admitting or Discharging Observation Patients

Paulo J. Gomes, Florida International University, Miami, FL, 33199, United States, pgomes@fiu.edu, Tala Mirzaei

This work examines the physician decision-making process in admitting or discharging patients from the observation unit of a hospital. Using patient-level data set covering one year of operations, we examine the drivers for length-of-stay, admission rate, readmissions and total cost per visit. The results explain the significant variability among physicians as observed in practice.

5 - A Data Analytics Framework for Smart Asthma Management Based on Remote Health Information System with Bluetooth-Enabled Personal Inhalers

Junbo Son, Assistant Professor, University of Delaware, Newark, DE, 19716, United States, junboson@udel.edu, Patricia Brennan, Shiyu Zhou

Patients diagnosed with asthma may experience significantly reduced quality of life if their asthma is not properly controlled. To facilitate better asthma self-management, a new health IS (smart asthma management system) is developed. Taking advantages of the monitoring capability of the system, we proposed a data analytics framework for detecting abnormal inhaler use that is out of the patient's normal usage pattern. We showed the satisfactory performance of our method through rigorous comparison with various benchmark methods. Also, practical implications of our analytics framework to data-driven asthma management practice is discussed.

■ WD25

CC- Room 401

Operations and Revenue Management

Contributed Session

Chair: Gaurav Pal, Fishbowl

1 - Measuring Hospital Performance under Comorbidities

Stefan Feuerriegel, ETH Zurich, Zurich, Switzerland, Patrick Zöchbauer

Health care reimbursements in the US exceeded USD 3.7 trillion in 2018. However, these reimbursements to providers are variable if healthcare providers fail to achieve a pre-defined quality of care. Key to performance-based reimbursements is a quality measure of hospital performance that caters for the fact of providers serving different patient cohorts. Despite extensive research on performance measures, prior attempts neglects comorbidities, i.e., co-occurring patterns of secondary diseases. We introduce a novel statistical model to learn the effect of comorbidities. In fact, we find that this results in extensive annual misallocations of reimbursements in the order of USD X bn

2 - An Empirical Exploration of Quality Management Practices and Firm Performance from Chinese Manufacturing Industry

Huiming Liu, Tsinghua University, Beijing, China, Su Wu, Chongwen Zhong, Ying Liu

This paper employs the event study methodology to determine whether companies can enhance operational and financial performance by implementing quality management frameworks. The results show that while quality awards winners have advantages in terms of their profitability indicators, their market performance and operating efficiency are not improved as expected. Specifically, the innovation capability of award winners strongly underperforms compared to that of their counterparts. This study also highlights that the positive impact on profitability may disappear after the certification and that the most significantly positive stimulus occurs in the certification year.

3 - Click-through and Purchasing Rates Optimization for E-tailer Plate-form: Leaning, Optimal Control and Long-run Average Objectives

Yina Ning, City University of Hongkong, Hongkong, China, yinaning2@gmail.com, Houmin Yan

We propose an online click-through and purchasing rate optimization framework that learns customer click-through and purchasing behavior. In this model, the selection of product advertising is modeled as a multi-armed bandit problem and the click-through rate can be adjusted by the product advertisement; and the purchasing behavior is modeled as a Markov chain and it can be enhanced by a dynamic pricing strategy. We demonstrate the proposed learning and optimal control framework optimizes a long-run average-cost. An initial study is carried out with data obtained from Tmall. <!—EndFragment—>

4 - Optimal Multi-Product Pricing and Generalizations

Seetharama Chandrasekhar Manchiraju, The University of Texas at Dallas, Richardson, TX, United States, chandumanchi@gmail.com, Milind Dawande, Ganesh Janakiraman

Our work is motivated by a multi-product price-optimization problem studied in Gallego and van Ryzin (1997). In this problem, there are supply constraints on the resources that are required to produce these products; these constraints form a system of linear inequalities. An interesting variant of this problem, also mentioned in Gallego and van Ryzin (1997), is when (a) the prices of the products are restricted to discrete sets and (b) we are allowed to change prices through time subject to the aggregate consumption of resources. This problem is an exponential size linear program. We present methods for solving this problem which are provably optimal in some special cases and near-optimal in others.

5 - Impact of Online Reputation on Performance of Restaurants

Gaurav Pal, Fishbowl, Alexandria, VA, United States, gp364@cornell.edu

Please check the mobile app for this abstract.

■ WD26

CC- Room 4C-1

Queueing and Scheduling

Contributed Session

Chair: Yan Chen, Columbia University, New York, NY, 10027, United States

1 - The Airport Shuttle Service Scheduling Problem

Ça rı Koç, Social Sciences University of Ankara, Ankara, Turkey, cagri.koc@asbu.edu.tr, Nihat Öner, Hakan Gultekin

Airport shuttle services transfer passengers from or to the airport and city center. The main objective is to maximize the profit while satisfying the limited seat capacity, the predefined flight times, and the number of passenger constraints. Such considerations give rise to an integrated variant of a vehicle routing problem and machine scheduling. This paper introduces the airport shuttle problem, presents a mathematical formulation, and develops a hybrid metaheuristic based on simulated annealing. Extensive computational experiments have shown that the metaheuristic is highly effective. Several managerial analyses have been conducted to investigate the impact of some parameters.

2 - Appointment Scheduling in Dialysis Clinics

Farbod Farhadi, Roger Williams University, Bristol, RI, United States, ffarhadi@rwu.edu, Sina Ansari

Unpunctuality of patients in arriving to homo-dialysis clinics has direct impact on system operational performance and quality of care patients receive. In this paper, we propose an appointment scheduling framework to minimize patient waiting time and maximizing resource utilization, accounting for patient unpunctuality.

3 - Queue Joining Decisions When There is a Prerequisite Condition for Receiving Service

Mona Imanpoor Yourdshahy, University of British Columbia, Sauder School of Business, Vancouver, BC, Canada, mona.imanpoor@sauder.ubc.ca, Woonghee Tim Huh, Steven Shechter

We consider an M/M/1 queueing system in which customers require some conditions to be met prior to receiving service. We investigate whether an individual arriving to this system should join the queue at that time, or wait to join at some future time. We formulate the problem as a Markov decision process and show how the structure of the optimal policy depends on various model parameters. Furthermore, we use a level-k framework to characterize the equilibrium strategy and to model the bounded rationality of customers. We also present the socially optimal solution and compare it to the equilibrium policy.

4 - Designing Service Systems in the Age of Yelp: Incorporating Reviews in Queueing Decisions

Abhishek Roy, Temple University, Fox School of Business, Philadelphia, PA, United States, abhishek.roy@temple.edu, Debjit Roy

Online reviews have become an increasingly ubiquitous source of information about the quality of products and services. We propose a model where customers decide to join a queue based on the information obtained from online reviews. In doing so, we consider two cases - (a) customers infer quality solely from reviews, and (b) customers infer quality both from the length of the queue and from the reviews. We provide insights on optimizing the service system design, the product quality decision, and implementation of any incentive scheme for reviews.

5 - Simple Views of Queues: Set-valued Performance

Yan Chen, Columbia University, New York, NY, United States, yc3107@columbia.edu, Ward Whitt

We propose a new approach to performance analysis of queueing models. In particular, we propose developing set-valued performance descriptions given limited partial information. We illustrate this approach for the steady-state waiting time distribution in the GI/GI/K queue given the first two moments plus additional information about these underlying distributions, including support bounds, higher moments and Laplace transform values. In each case, the extremal models maximize or minimize the waiting-time tail probability in the exponential form associated with large deviations asymptotics. These extremal models are then applied to compute a range of possible mean.

■ WD27

CC- Room 4C-2

Large Scale Electric Vehicle Fleet Management in Transportation and Power Systems

Sponsored: Service Science

Sponsored Session

Chair: Dongfang Zhao, Year, Tampa, FL, 33617, United States

1 - Large Electric Vehicle Sharing Fleet Management System Interfacing Transportation and Power Systems

Dongfang Zhao, University of South Florida, Tampa, FL, 33617, United States, dongfangzhao@mail.usf.edu, Xiaopeng Li

In this study, we propose a linear optimization model to optimize the operations of a large fleet of shared EV fleet interfacing both transportation systems and power systems. The model investigates operations of a large shared EV fleet that may opt to serve travel demands in transportation systems or charge or discharge to the power grid in power systems. The sum of rebalancing cost, charging cost and distribution network line cost are minimized through the operation process. Real-world data on the configurations of these two systems are used to build numerical examples. Sensitivity analysis are constructed to draw insights into the influence of large EV fleet to power systems.

2 - Incentive Design for Decentralized Autonomous Electric Vehicle in Power Distribution Network

Zhaomiao Guo, University of Central Florida, Orlando, FL, 32816, United States, guo@ucf.edu

Autonomous electric vehicles (AEVs) provide unique opportunities to cope with the uncertainties of distributed energy generation in distribution networks. However, the effects are limited by both inherent radial topology and the behaviors of decentralized AEVs. In this paper, we investigate the potential benefits of dynamic distribution network reconfiguration (DDNR), taking into account AEVs' spatial-temporal availability and their charging demand. We propose a mixed integer programming model to optimally coordinate the charging/discharging of AEVs with DDNR, while satisfying AEVs' original travel plan.

3 - Transportation Network Infrastructure Design under Continuous Traffic Equilibrium

Xin Wang, University of Wisconsin-Madison, Madison, WI, 53562-4278, United States, Yikang Hua

Transportation network infrastructure design used to be a long-term decision, and relies on rough estimation of travel distribution. However, the recent development of smart transportation system requires the infrastructure to be adaptive to various uncertainties, which leads to the short-term infrastructure planning challenge, such as the number of dedicated automated vehicle lanes, reversible lanes, etc. For the first time, we develop an integrated infrastructure capacity planning framework under the concept of continuous modeling of traffic equilibrium. This continuous bi-level optimization model can provide fast traffic control instrument to various traffic conditions.

4 - Integrated Design of Dynamic Wireless Charging Location and On-board Battery Size for Electric Bus Systems Considering Battery Lifetime

Tingting Zhao, University of South Florida, Tampa, FL, 33612, United States, tingtingzhao@mail.usf.edu

This work focused on the integrated dynamic wireless charging facility (DWCF) location and battery size design of electric bus (E-bus) systems that is formulated as a nonlinear integer programing problem. The objective is to minimize system lifecycle cost. The componential facility cost, battery cost, and energy consumption cost, intertwine with each other through the design of DWCF location and battery size. The battery lifetime estimation introduces complicated non-linear feature to this problem that is tackled by transferring to optimization over the frontier of a bi-objective problem. The capability of the developed solution algorithm is illustrated on a case E-bus system design problem.

■ WD29

CC- Room 4C-4

Disclosure in Mechanisms

Sponsored: Auction and Market Design

Sponsored Session

Chair: Kyle Woodward, University of North Carolina at Chapel Hill, Chapel Hill, NC, 27599-3305, United States

1 - Self-Auditable Auctions

Kyle Woodward, University of North Carolina at Chapel Hill, Department of Economics, Chapel Hill, NC, 27599-3305, United States, kyle.woodward@unc.edu

We consider the information necessary to verify that an auction has been run honestly. A mechanism is audited by information release if each outcome maximizes the seller's utility, conditional on consistency with information release. One mechanism is more auditable than another if any information that audits the latter also audits the former. Without supply commitment, only menus are auditable without information release. Discriminatory auctions are no more auditable than uniform price auctions. Audit-incomparability is relaxed under constraints on the form of information or nonnegligible marginal costs, and strengthened when the disclosure policy must be incentive compatible.

2 - Credible Mechanisms

Shengwu Li, Harvard University, Cambridge, MA, United States, Mohammad Akbarpour

Consider an extensive-form mechanism, run by an auctioneer who communicates sequentially and privately with agents. Suppose the auctioneer can deviate from the rules provided that no single agent detects the deviation. A mechanism is credible if it is incentive-compatible for the auctioneer to follow the rules. We study the optimal auctions in which only winners pay, under symmetric independent private values. The first-price auction is the unique credible static mechanism. The ascending auction is the unique credible strategy-proof mechanism. These results extend naturally when we permit asymmetry and payments from losing bidders.

3 - Learning Before Trading: on the Inefficiency of Ignoring Free Information

Anne-Katrin Roesler, University of Toronto, Toronto, ON, Canada

We analyze a bilateral trade model in which the buyer's valuation for the object is uncertain and she can privately purchase any signal about her valuation. The seller makes a take-it-or-leave-it offer to the buyer. The cost of a signal is smooth and increasing in informativeness. We characterize the set of equilibria when learning is free, and show they are strongly Pareto ranked. Our main result is that when learning is costly but the cost of information goes to zero, equilibria converge to the worst free-learning equilibrium.

■ WD30

CC- Room 6A

Reliability & Retail Management

Contributed Session

Chair: Sushil Punia, Indian Institute of Technology Delhi, Vishwakarma Bhawan, IIT Delhi, Hauz Khas, New Delhi, 110016, India

1 - Life Cycle Cost Model for Tunnel Ventilation Systems Considering Vehicle Fleet Mix Forecast

Weihong Guo, Rutgers, The State University of New Jersey, Piscataway, NJ, United States, wg152@rutgers.edu, Qi Tian, Shenghan Guo

Tunnel ventilation systems must be able to provide adequate air quality during normal operations and emergency incidents. As the vehicle emission technology advances rapidly, the vehicle fleet is constantly being renewed. Thus, realistic forecasting of life cycle cost of tunnel ventilation systems must include models that incorporate the ever-changing fleet mix of zero emission, hybrid and combustion vehicles. In this study, both short-term and long-term forecasts of vehicle fleet mix are developed, considering conservative, moderate, or aggressive EV adoption. These forecasts are used to estimate CO emission, which will guide the optimal operations to minimize the systems' life cycle cost.

2 - Reliability Computation of a Repairable System Using Increasing Failure Rate

Berna Dengiz, Professor, Baskent University, Ankara, Turkey, bdengiz@baskent.edu.tr, Merve Uzuner Sahin, Orhan Dengiz

In today's highly competitive industry, companies try to find cost-effective solutions to improve system productivity. Several measures such as reliability, availability, maintainability are used to evaluate the performance of such complex manufacturing systems. Generally it is assumed that components are maintained with a constant failure rate for the system reliability.. However in many real world systems, the failure rate of each component increases depending on its lifetime. In this study, unlike studies in the literatüre component repair is considered to maintain a system. ncreasing failure rate is used to compute system reliability due to obtain more realistic system performance

3 - Reliability Optimization for Balanced System with Spherically Distributed Units

Jingbo Guo, Rutgers University, Piscataway, NJ, United States, Elsayed A. Elsayed

Balanced systems with spherically distributed units are emerging in a diverse range of applications such as Spherical Unmanned Aerial Vehicles used for underwater exploration. A limited number of units (usually motors and rotors) is mounted on the spherical surface and are required to operate in a balanced arrangement for the system to operate properly. The units' placement is key in reliability estimation for such balanced systems and thus is of interest for both designers and engineers. In this presentation, the optimal allocation of the units on the spherical surface while maintaining balance and maximizing the system reliability is studied. Numerical examples are provided for validation.

4 - Temporal Hierarchies for Demand Forecasting in Multi-channel Retailing

Sushil Punia, IIT Delhi, SA02 Vindhyachal Hostel, IIT Delhi, Huaz Khas, New Delhi, 110016, India, s.punia.official@gmail.com, Surya P. Singh, Jitendra Madaan

This paper proposes the use of temporal hierarchical framework as a strategy for forecasting in retail. The proposed framework uses the temporal hierarchies to generate short-term up to long-term coherent forecasts for a multi-channel retailer. For base forecasts for hierarchical framework, we used deep learning with long-short-term-memory networks for time-series forecasting. We evaluated the performance of proposed forecasting approach on point-of-sales data from a large multi-channel retailer. Several performance metrics and statistical test were employed to test the accuracy of forecasts from proposed framework and evidence suggests significant improvements across all metrics.

5 - Impact of Supplier's Capacity Constraint on the Platform's Business Model Choice

Bin Dai, Wuhan University, Wuhan, China, dbbudstar@gmail.com, Jing YU

We consider a supply chain consists of a supplier and a retailing platform, and the platform could choose the business model of reselling, agency or even hybrid. We investigate the impact of supplier's capacity constraint on the platform's business model design.

■ WD31

CC- Room 6B

Efficient Resource Planning and Utilization

Sponsored: Military and Security

Sponsored Session

Chair: James Fan, Naval Postgraduate School, Monterey, CA, 93940, United States

Co-Chair: Joseph Carl Foraker, United States Navy, Annapolis, MD, 21409-5480, United States

1 - Promotion of Women vs Men in the Canadian Armed Forces

Peter G. Boyd, Department of National Defense, Ottawa, ON, Canada

In order to ensure employment equity in the Canadian Armed Forces (CAF), it is important to understand if women benefit from the same promotion opportunities experienced by men. We examine historical CAF member service data broken down by sex and military occupation to see if women have an equal consideration for promotion to a higher rank. Equality is assessed based on metrics such as time in rank before promotion, and promotion rates.

2 - Infantry Career Lifecycle and Resource Planning Simulation Model

John Rumbavage, Deloitte Consulting, Arlington, VA, United States, jrumbavage@deloitte.com

A large-scale discrete event simulation model for manpower management in a major branch of the U.S. Armed Forces is considered. The military suffers from a shortage of qualified rifle squad leaders and has searched for a solution set that will reduce the severity of their problem under given constraints. Our simulation-based model accounts for complex career life cycles and unit deployment schedules that translate to 172 input parameters and constraints that are temporal, fixed point, or randomly distributed. The final product enables users to see how policy-driven parameter changes will affect operational force readiness as well as individual personnel assignment to alternate duty occupations.

3 - Optimal Scheduling of Flight Training for a United States Navy Strike Fighter Squadron Detachment

Joseph Carl Foraker, Assistant Professor, United States Naval Academy, Annapolis, MD, United States, foraker@usna.edu, Gary Lazzaro

We discuss the problem of creating daily flight schedules for 2- week training detachments of VFA-106 in Key West, FL called Fighter Det. The daily flight schedule requires pairings of students, instructors, 3 variants of F/A-18 aircraft, limited adversary aircraft, airspace deconfliction, sequential syllabus events, discrete flight time windows, and crew rest requirements. We formulate a binary integer program to automate the scheduling of flight events with the goal of maximizing daily events scheduled. The output of the model is a printable flight schedule in MS Excel format. Implementation of our model results in an average increase of 1.16 more events per day than a hand-written schedule.

4 - Simulating and Optimizing Shrapnel Spray from a Warhead

Erkam Guresen, Lethal Ballistics LLC., Ankara, Turkey, erkamguresen@gmail.com

Detonation of warheads is a critical issue in two ways; it should detonate when needed and it should detonate effectively. Failure to denote is considered by defense companies but generally effectiveness of the detonation is not considered. In this paper we present the state of the art warhead design procedure with detonation simulation that gives control capability of shrapnel spray after the detonation. This simulation capabilities enables specific warheads for specific target types.

■ WD32

CC- Room 6C

Technology Management and Global Issues

Contributed Session

Chair: Yoonmo Koo, Seoul National University

1 - The Effect of the China Feed-in Tariff Scheme on Renewable Energy Technical Innovation: An Empirical Analysis for Electric Power Sector

Ge Zhao, Nanjing University of Aeronautics and Astronautics, Nanjing, China, zhaogezzu@qq.com, Peng Zhou, Peng Zhou

Feed-in tariffs have pushed mass of innovation of electricity on renewable energy in China. The subsides of renewable power generation have experiencing slope down provoking an public debate on whether promote renewable energy innovation. Focusing specifically on electric power sector, feed-in tariffs how influence the development of heterogeneous technologies were explored. We build a unique sample of China's provinces from 2008 to 2017 to identify the determinants of renewable energy technology innovation. We give a comprehensive interpret of technology innovation and present the managerial implication at the provincial level.

2 - Decision Right Allocation and Platform Market Effectiveness: Evidence from Online P2P Lending

Anparasan Mahalingam, Purdue University, West Lafayette, IN, United States, anparasan@purdue.edu, Tony Tong

This study proposes that platform owners can mitigate problems of information asymmetry in platform markets and enhance market effectiveness through appropriate allocation of decision rights among participants. By exploiting a quasi-experimental design in the online peer-to-peer (P2P) lending industry, we show causal evidence that retaining pricing rights with the platform increases platform market effectiveness, measured by loan sanction rates. This effect is strengthened by the hard information and mitigated by the soft information available in the local financial market, highlighting a strong connection between online platforms and offline information environments.

3 - Global Value Chain, Industrial Agglomeration and Industrial Innovation Performance: Insights from China's Manufacturing Industries

Nana Yang, University of Science and Technology of China, Hefei, China, ynn916@mail.ustc.edu.cn, Qiming Liu

This study explores GVC involvement along two dimensions-participation and position-and examines its effects on innovation performance in China's manufacturing industries, including its direct effects on innovation performance and moderating effects on the relationship between industrial agglomeration and innovation performance. The results show that GVC participation has an inverted U-shaped effect on innovation performance, whereas the effect of GVC position follows a U-shape. Finally, industrial agglomeration is found to positively affect innovation performance and the relationship is differently moderated by GVC participation and GVC position.

4 - Modern Predictors to Support the Human Development Index

Zachary James Steever, University at Buffalo, Gowanda, NY, 14070, United States, Hailie Suk, Ritwik Raj, Sayanti Mukherjee

The Human Development Index (HDI) is a metric used by the United Nations (UN) to assess the development of the world's nations. The standard HDI metric takes a linear combination of three features - years of schooling, life expectancy at birth, and per capita income. We propose that there exist modern indicators of human development, and that these predictors may not interact linearly with the development index. Using a suite of predictive models, this work explores a set of such factors which were gathered from the UN data explorer. We find that internet access, cell phone use, gender equality in the labor force, homicide rates, and secondary education enrollment are strong indicators of development.

5 - An Integrated Energy System Model to Evaluate Climate Policy on Industrial Sectors

Yoonmo Koo, Seoul National University, Seoul, Korea, Republic of, yyounmo@snu.ac.kr, Hwarang Lee

We integrate the top-down and bottom-up models to evaluate climate policy on 10 energy-intensive industries in South Korea. A dynamic recursive computable general equilibrium model accounting for interactions between economic agencies is used as the top-down model, while positive mathematical programming predicting technology substitution is used as the bottom-up model. The hybrid model can evaluate impact of carbon tax and give reasonable explanation for the unexpected rebound effect when energy efficiency of technology is improved.

■ WD33

CC- Room 602

Artificial Intelligence and Disaster Management

Contributed Session

Chair: Han Liu, Tsinghua University

1 - Insights from Causal Relations Extracted from Text Documents

Lipika Dey, Tata Consultancy Services, Delhi, India, lipika.dey@tcs.com, Tirthankar Dasgupta

Detecting causal relations from texts is challenging due to ambiguity, uncertainty and subjectivity. We propose linguistically informed deep transfer learning models to extract causal relations from text. Drug manufacturers mine scientific literature reporting causal relations between genetic conditions and diseases or effects of drugs on specific conditions. Similarly mechanic's notes having expert knowledge on causal relationships between various components are used to boost machine learning based health monitoring systems for smart machines. Causal relationship detection from safety incident reports provide actionable insights to enterprises. More industrial use cases exist.

2 - Utilizing Deep Learning and Machine Learning Algorithms in Disease Prediction

Buket Aydas, Albion College, Albion, MI, United States, baydas@albion.edu

Metabolomics, proteomics, and genomics (in general omics) hold the promise as a new technology to diagnose highly heterogeneous diseases. Here we use omics data to test the accuracies of feedforward networks, a deep learning (DL) framework, as well as five widely used machine learning models, namely random forest (RF), support vector machines (SVM), linear discriminant analysis (LDA), prediction analysis for microarrays (PAM), and generalized linear models (GLM) to predict some very important diseases.Some of the diseases that we work to predict are pancreatic cancer, cervical cancer, autism, down syndrome, cerebral palsy, pediatric concussion, miscarriage and Alzheimer disease.

3 - Simulation and Control Framework of Infectious Diseases Using Deep Reinforcement Learning

Hyunsoo Lee, Kumoh National Institute of Technology, Gumi, Korea, Republic of, hsl@kumoh.ac.kr

While most of the research studies handling infectious diseases have formulated Ordinary / Partition Differential Equations (ODE/PDE) based diffusion models, the effective control frameworks are provided comparatively less due to its dynamics. This research proposes a deep reinforcement learning based framework for controlling effectively several infectious diseases. The provided framework changes the locations of a disease control center considering multiple occurrences of infectious diseases and dynamics of diseases' status. Then, the framework is compared with other existing methods.

4 - A Load-Balancing Formulation for Disaster Response

Timothy Murray, University of Illinois, Champaign, IL, United States

Most models for disaster response and preparedness are based, implicitely or explictely, on the Network Flow Problem. This paper proposes an alternate formulation based on the Load Balancing Problem. The proposed model more easily incorporates concepts that are cumbersome in a network flow formulation, and is more adaptable to uncertainty in job duration for future work. An Integer Programming formulation is provided for exact solutions, then used to benchmark state of the art Load-Balancing algorithms.

5 - Discrete Network Location and Assignment Model under Cooperative Coverage in Fire Service

Han Liu, Tsinghua University, Beijing, China, hanliu@tsinghua.edu.cn, Xiaopeng Li, Saeed Amiri, Siyang Xie

Fire service quality relies on fast response and cooperation of various fire vehicles to maintain efficient operations and reliable rescue service. This paper investigates a cooperative station location and vehicle assignment problem where fire vehicles can be dispatched jointly for cooperation. A mixed-integer non-linear program is proposed to minimize facility construction/operation costs and fire damage losses. The results show vehicle locations become more decentralized and the average response times increase at slower rates of fire damage. An empirical case study with real-world data is also conducted to reveal managerial insight under a range of implementation scenarios.

■ WD34

CC- Room 603

Optimization, Robust II

Contributed Session

Chair: Mona Issabakhsh, University of Miami, South Miami, FL, 33143, United States

1 - Analyzing Reviewers' Influence on Amazon.com

Ji Hae Choi, Yonsei University, Seoul, Korea, Republic of, jiha9139@yonsei.ac.kr

This study analyzes periodic bipartite graph networks between reviewers and products. For every pre-defined time period, we create a bipartite graph consists of two sets of nodes (product nodes and reviewer nodes) and a set of edges representing the user's review on the product. As new edges are created, the graph network evolves. The analysis of network evolution reveals a tendency that if two users are coupled, i.e., they have reviewed the same product, one user is more likely to write a review on the product previously reviewed by the other user. This tendency becomes more significant when a user with few reviews is coupled with a heavy reviewer, which confirms the influence of heavy reviewers.

2 - A Data-driven Approach to Modeling Multiple Customer Satisfactions for New Product Development Using Canonical Correlation Analysis

Jaeho Lee, Sungkyunkwan University, Suwon, Korea, Republic of, jongseok@skku.edu, Jong-Seok Lee

Understanding the relationship between design attributes and customer satisfaction has received a great attention in new product development. While many research works have been done to model a single customer satisfaction on design attributes, the fact is that there are several types of satisfaction. Therefore, we propose a new data-driven approach consisting of three main components: canonical correlation analysis to find the relationship between product and customer, regression to establish the models, and solving a linear inverse problem to predict customer satisfaction scores. This method can help product engineers to consider customer satisfactions in new product development.

3 - Applying the WOWA Criterion to Two-stage Problems

Jaeyoong Lim, Korea Advanced Institute of Science & Technology, Daejeon, Korea, Republic of, jae0908@kaist.ac.kr, Sungsoo Park

Weighted OWA (WOWA), a criterion which generalizes many of the traditional criteria used in decision making under uncertainty, has been widely used in multi-objective problems. In this research, we apply the WOWA criterion to two-stage problems with discrete uncertainty. Use of the criterion generalizes both the stochastic and the robust version of the problem, and risk preference of the decision maker can be taken into account. We compare different algorithms to solve the problem, including an algorithm based on Benders dual decomposition method, and report their performance.

4 - Multi Appointment Infusion Therapy Scheduling Problem with Uncertainty

Mona Issabakhsh, University of Miami, South Miami, FL, United States, mona.issabakhsh@gmail.com, Seokgi Lee, Hyojung Kang

In this paper, a mixed-integer programming doctor-infusion appointment scheduling mathematical model is developed based on patient appointment data obtained from a cancer center of an academic hospital. The objective of the model is to simultaneously find the doctor-infusion appointment sets of patients who need to visit a doctor before infusion while minimizing patient wait times, infusion completion times, and the number of infusion beds used. A mixed-integer programming robust mathematical model is designed to find the optimal patient appointment set when doctor's appointment time and/or infusion time of patients take longer than expected.

■ WD35

CC- Room 604

Joint Session OPT/Integer/Practice Curated: Operations Research and Cyber

Sponsored: Optimization/Integer and Discrete Optimization

Sponsored Session

Chair: Les Servi, The MITRE Corporation, Bedford, MA, 01730-1420, United States

1 - A Two-Step Approach to Optimal Selection of Alerts for Investigation in a Cyber Security Operations Center (CSOC)

Rajesh Ganesan, George Mason University, Fairfax, VA, 22030, United States, rganesan@gmu.edu, Ankit Shah

There exists a critical gap between the time needed (demand) and the time available (limited analyst resource) for alert investigation at a Cyber Security Operations Center (CSOC). Current ad-hoc triaging (or prioritization) method is insufficient, and an intelligent method for optimal selection of alerts that considers organization-specific factors must be developed, which is described as a two-step process in this research.

2 - Interactive Simulations in Support of Cybersecurity Risk Analysis

Shaun Doheney, ProbabilityManagement.org, Stafford, VA, United States, shaun@probabilitymanagement.org, Sam Savage

The Open SIPmath™ Standard from 501(c)(3) ProbabilityManagement.org allows simulations in any environment to be networked by communicating uncertainties as arrays of Monte Carlo realizations called Stochastic Information Packets (SIPs). This sort of modeling is particularly applicable to assessing risk associated with difficult-to-measure cybersecurity risks. Examples will include communications network modeling and analysis, and vulnerability analysis associated with layered network security. We encourage all participants to download some of the companion models to our presentation in advance available here: https://www.probabilitymanagement.org/models.

3 - On Combining Mission Mapping and Robust Network Analysis Methods to an Air Force System

Les Servi, The MITRE Corporation, M/S M230, Bedford, MA, 01730-1420, United States, lservi@mitre.org

We infer the topology mapping of a mission's components and the dependencies between the components from the enterprise network traffic it generates. Using robust optimization methods and MILP we identify critical nodes while hedging against imperfect dependency estimates. The results and approach are illustrated with a numerical example.

4 - Strategy-to-task Assessments

Mark A. Gallagher, Air Force Institute of Technology, Columbus, OH, United States, markgallagherJMJ@gmail.com, Leah Nestico, John Pav, Adam Campbell, Joseph M. Tama

We present a quantitative method to assess how well a budgetary plan complies with strategic guidance and aligns to enterprise priorities. We construct a hierarchy that links program elements to enterprise goals. We utilize the dot product of the priority weights and individual budgetary expenditures as a quantitative measure of overall budget alignment for each goal. Further, we compare a proposed budget to a prior year budget to develop relative assessments of budgetary alignment. We propose a greedy algorithm for a single goal, and preemptive goal programming for multiple goals. Analysts may use our approach to inform decision makers of possible tradeoffs between various enterprise goals.

■ WD36

CC- Room 605

Aspects of Unit Commitment

Sponsored: Optimization/Optimization Under Uncertainty

Sponsored Session

Chair: Bismark Singh, Sandia National Laboratories, Sandia National Laboratories, Albuquerque, NM, 87185, United States

1 - Learning to Solve Stochastic Unit Commitment

Feng Qiu, Argonne National Laboratory, Lemont, IL, 60439, United States, fqiu@anl.gov, Alinson Xavier, Shabbir Ahmed

Stochastic UC remains a computationally challenging problem, especially for large-scale systems. State-of-the art methods, based on scenario decomposition and Progressive Hedging, are currently able to solve instances of small to moderate size, with a modest number of scenarios. We investigate how can ML extract information from a small number of scenarios that have already been solved to speed up the solution of the remaining ones, improving the performance of the entire procedure. Learned information includes redundantconstraints, warm starts and binary variable decisions. We present computational results on a variety of realistic and large-scale instances.

2 - Modeling Flexible Generator Operating Regions via Chance-constrained Stochastic Unit Commitment

Bernard Knueven, Sandia National Laboratories, Albuquerque, NM, 87185-1326, United States, bknueve@sandia.gov, Bismark Singh, Jean-Paul Watson

We introduce a chance-constrained stochastic unit commitment model to address renewables production uncertainty in power systems operation. For most thermal generators, underlying technical constraints that are universally treated as "hard" by deterministic unit commitment models are based on engineering judgments, such that system operators can periodically request operation outside these limits in non-nominal situations, e.g., to ensure reliability. We incorporate this practical consideration into a chance-constrained stochastic unit commitment model, specically by at most occasionally allowing minor deviations from minimum and maximum thermal generator power output levels.

3 - Synchronous and Asynchronous Parallel Algorithms for SDDP

Daniel Felipe Ávila Girardot, Université Catholique de Louvain, Louvain La Neuve, Belgium, daniel.avila@uclouvain.be, Anthony Papavasiliou, Nils Löhndorf

In our work we consider the Stochastic Dual Dynamic Programming algorithm (SDDP). In particular, we develop a terminology to establish what synchronous and asynchronous would mean for this algorithm, and study different approximations to achieve parallelism. The aim of the present work is to get an insight of different approaches to achieve parallelism, determine which parallel setting would imply a better time performance of the algorithm. Eventually we aim to show that SDDP performs well for handling battery storage decisions in distribution systems.

■ WD37

CC- Room 606

Transportation and Logistics under Uncertainty

Sponsored: Optimization/Optimization Under Uncertainty

Sponsored Session

Chair: Yiling Zhang, University of Michigan, Ann Arbor, MI, 48105, United States

1 - Structured Actor-Critic for Managing and Dispensing Public Health Inventory

Yijia Wang, University of Pittsburgh, Pittsburgh, PA, 15213, United States, yiw94@pitt.edu, Daniel Jiang

Public health organizations face the problem of dispensing medications to groups of affected populations during emergency situations, typically in the presence of complexities like demand stochasticity and limited storage. We formulate a Markov decision process (MDP) model with two levels of decisions: the upper-level decisions come from an inventory model that "controls" a lower-level problem that optimizes dispensing decisions that considers the heterogeneous utility functions of the random set of arriving patients. We derive structural properties of the model and propose an approximate dynamic programming (ADP) algorithm that leverages structure in both the policy and the value space.

2 - Robust Location Problems under Spatial Uncertainty

Khaja Irfan Babu Soudagar Abdul, National University of Singapore, Singapore, e0046957@u.nus.edu

We propose a data-driven framework to solve location problems with continuously distributed demand. Leveraging the historical data to obtain the spatial information of demand distribution, we present a distributionally robust optimization approach to solve location problems under demand location (spatial) uncertainty. Employing clustering approach, we partition the study region into clusters, and estimate the probability of demand occurrence and mean demand location in each cluster from the historical data. Modelling this spatial distributional information into an ambiguity set, we provide tractable formulations for the robust median and gradual coverage problems.

3 - The Roaming Delivery Problem with Stochastic Travel Times

Joris Kinable, Eindhoven University of Technology, De Lismortel 62, Eindhoven, 5612 AR, Netherlands, j.kinable@tue.nl, Afonso Henrique Sampaio Oliveira, Lucas Petrus Veelenturf, Tom Van Woensel

We address a stochastic variant of the Vehicle Routing Problem with Roaming Delivery Locations (VRP-RDL), a last-mile delivery problem in which packages are delivered directly to the customer's car. Unique to this problem is that we can recover from missed deliveries by meeting up with the customer's next vehicle location. To accommodate for uncertainty in travel times, we solve the problem via a two-stage stochastic model. Our solution approach is based on an efficient heuristic for VRP-RDL, embedded in a customized SAA framework. Evaluation of this model shows that cost savings of over 30% can be realized when explicitly taking uncertainty as well as varying delivery locations into account.

4 - Robust Aircraft Routing

Chiwei Yan, Uber Technologies, San Francisco, CA, United States
Chiwei Yan, University of Washington, Seattle, WA, United States, Jerry L. Kung

We propose a robust optimization approach to minimize total propagated delay in the aircraft routing problem. We develop exact and tractable solution approaches for our robust model. The major contribution of our model is that it allows us to explicitly model and handle correlation in flight leg delays that existing approaches cannot efficiently incorporate. Computational experiments show superior performance over existing stochastic approaches.

5 - On the Values of Vehicle-to-grid Electricity Selling in Electric Vehicle Sharing

Yiling Zhang, University of Michigan, Ann Arbor, MI, 48105, United States, zyiling@umich.edu, Mengshi Lu, Siqian Shen

We study electric vehicle (EV) sharing systems with vehicle-to-grid (V2G) integration under uncertain electricity selling prices and trip requests. We formulate the problem as a two-stage stochastic linear program. In the first stage, we optimize service planning decisions. In the second stage, we optimize EV operational decisions using a time-and-charging-status-expanded transportation network. Via testing on real-world data, we demonstrate that the benefit of V2G can prevail with battery degradation and can be significant when combined with fast charging, stringent service level requirement, traffic congestion, or when the urban spatial structure has concentrated residentialareas.

■ WD38

CC- Room 607

Optimization, Linear Programming and Methodology

Contributed Session

Chair: Sevilay Onal, NJIT, Newark, NJ, 07103, United States

1 - Cardinal Optimizer Mathematical Programming Solver

Dongdong Ge, Cardinal Operations, Shanghai, China, dongdong@gmail.com

Please check the mobile app for this abstract.

2 - A Novel Methodology for Scheduling the Steelmaking - Continuous Casting Process

Kwansoo Lee, POSTECH, Pohang, Korea, Republic of, michelan73@postech.ac.kr, Kangbok Lee

This paper proposes a novel solution methodology for scheduling the steelmaking - continuous casting (SCC) process. The SCC process is a bottleneck in the steel production, so an efficient schedule for the SCC process will reduce costs and allow the just-in-time delivery. An MILP model was established first, but since the complexity of the problem makes the problem hard to solve optimally, a constructive heuristic algorithm based on matheuristic was developed. The numerical results show the efficiency of the proposed algorithm.

3 - Targeted Jump Gradient Descent Algorithm for Global Optimal Control in Non-Convex Problem

Yuyang Chen, Kansas State University, Manhattan, KS, United States, cyy@ksu.edu

With increasing pressure of healthcare issue for infectious diseases, policymakers are busy to search the optimal control that can efficiently prevent the spreading of epidemic under the limited budget. In this case, the global optimal strategy plays a crucial role for balancing the healthcare and economic pressure. Therefore, we propose a new Targeted-jump gradient descent (TJGD) algorithm to explore the global optimal control. We provide two simulations to demonstrate the effectiveness of the proposed algorithm for both convex and non-convex optimization problems. The simulation results show that our algorithm can converge to the global optimal control strategy of the control systems.

4 - Improving Restart Strategies for Radial Basis Function Surrogate Global Optimization

Nanxi Liu, National University of Singapore, Singapore, Singapore, e0225114@u.nus.edu

We introduce two restart strategies for radial basis function surrogate algorithm that use some subsets of the previously evaluated points. One alternative is to keep a certain percentage of the worst evaluated points in previous search steps, which helps the algorithm spend less time in the vicinities of bad function values. Another approach is to remove the points around the best point. This is designed to encourage search in promising areas without immediately moving to the best decision vector previously found. Experimental results indicate that the new restart strategies obtain better objective function values using fewer evaluations, compared with the global optimization algorithm DYCORS.

5 - Gaussian Dispersal Model for Controlling a Biological Invader

Sevilay Onal, NJIT, Newark, NJ, United States, Esra Toy, Sabah Bushaj

Sericea Lespedeza has been acknowledged as a very aggressive perennial legume and was included in the Federal Noxious Weed Act in 2000 to reduce the harmful impacts on biodiversity and bioeconomy in the Great Plains of the U.S. An integrated simulation-optimization model is developed where the seed dispersal is estimated using Gaussian cell-to-cell transition probabilities, and the treatment locations are prescribed over a predetermined time period.

■ WD39

CC- Room 608

Telecommunications & Transportation

Contributed Session

Chair: Rupei Xu, The University of Texas at Dallas, TX, 75081, United States

1 - Competition in Tiered Spectrum Measurement Market with Licensed and Unlicensed Access

Arnob Ghosh, Indian Institute of Technology-Delhi, Delhi, India, ghosh39@purdue.edu

A three-tier spectrum sharing framework for the Citizens Broadband Radio Service (CBRS) enables commercial users to share spectrum with the incumbent users is proposed. Sharing is assisted by Environmental Sensing Capability operators (ESCs) which determine when the incumbents are absent. Two key aspects of this framework that impact how spectrum access firms (SAs) using this spectrum may compete are the different ESCs' information and how different SAs use the licensed and unlicensed band. We show that if the SAs use the unlicensed band more, they will obtain information from different ESCs. If one of the SAs uses the licensed band more, both the SAs obtain information from the same ESC.

2 - Performance Optimization with Load Coupling in Mobile Networks

DI YUAN, Professor, Uppsala University, Uppsala, Sweden, di.yuan@it.uu.se, Lei You

In this presentation, we review the load coupling model for performance evaluation and optimization of mobile communication networks. Here, the load refers to the amount of resource usage of each base station. The load values are coupled due to interference. Using the model, network performance can be assessed via solving a nonlinear equation system. A number of use cases of the model are highlighted. Next, we outline the challenges and research opportunities of extending the model to 5G networks, and present recent developments of the modeling approach for resource optimization for 5G systems with non-orthogonal multiple access (NOMA) and spectrum sharing between cellular and WiFi networks.

3 - Mobile Device Team Interconnection Game in the Internet of Things

Rupei Xu, The University of Texas at Dallas, Richardson, TX, United States, rupei.xu@utdallas.edu, Andras Farago

The emerging IoT technologies, such as edge and fog cloud, provide more powerful services for high demanding customers. The mobile device team(delivery drone system, self-driving car team, service robot team etc.) needs to maintain connectivity and connected to IoT to be assisted and controlled. However, in the existing literature, this problem is a dynamic quadratic assignment problem, which is very difficult to approximate and runs extremely slow with existing solvers. This paper innovatively created a two-level network creation game, which can avoid quadratic assignment problem and it can control the system performance by simple parameters, independently and in a distributed way.

■ WD40

CC- Room 609

Optimization, Metaheuristics

Contributed Session

Chair: Mohammad Dehghanimohammadabadi, Northeastern University, Boston, MA, 02115, United States

1 - An Augmented Self-adaptive Parameter Control in Evolutionary Computation: A Case Study for the Berth Scheduling Problem

Maxim A. Dulebenets, Florida A&M University-Florida State University, Tallahassee, FL, 32311, United States, mdlbnets@gmail.com, Masoud Kavoosi, Olumide Abioye, Junayed Pasha, Hui Wang, Hongmei Chi

This study aims to enhance the marine container terminal seaside operations and addresses the berth scheduling problem. An innovative augmented self-adaptive Evolutionary Algorithm (ASAEA) is designed to solve a linear mixed integer mathematical model, formulated for the problem. In ASAEA, the crossover and mutation probabilities are encoded in the solutions and evolve throughout the search process. The numerical experiments show that the ASAEA outperforms the alternative metaheuristic algorithms, which have been widely used in the literature, in terms of the solution quality.

2 - Accelerated Tabu Search with GPU for Solving Vehicle Routing Problem with Time Windows

Deyi Zhang, Walmartlabs, Sunnyvale, CA, United States, Mingang Fu, Madhavan Vasantham

Large-scale Vehicle Routing Problem with Time Windows (VRPTW) appears often in last-mile delivery routing for modern E-commerce fulfillment. To solve large-scale VRPTW efficiently, we propose a parallel tabu search algorithm that conducts local search and tabu list comparison on graphical processing unit (GPU). The algorithm is implemented with OpenACC and is tested on all 300 Gehring and Homberger instances. This algorithm allows speed-up in the order of magnitude and significant reduction in total distances within very short time of computation in solving all the benchmark instances.

3 - An Exact Algorithm for a Rich Vehicle Routing Problem with Private Fleet and Common Carrier

Said Dabia, Vrije Universiteit Amsterdam, Amsterdam, Netherlands, said.dabia@gmail.com, David S.W. Lai

The Vehicle Routing Problem with Private Fleet and Common Carrier (VRPPC) is a generalization of the classical Vehicle Routing Problem in which the owner of a private fleet can either visit a customer with one of his vehicles or assign the customer to a common carrier. The owner's objective is to minimize the variable and fixed costs for operating his fleet plus the total cost charged by the common carrier. We consider cost structures that account for quantity discounts on outsourcing costs. We present an exact approach based on a branch-and-cut-and-price algorithm and test the algorithm on instances from the literature.

4 - The Vehicle Routing Problem with Private Fleet, Common Carrier and Stochastic Demand

David Lai, Vrije Universiteit Amsterdam, Amsterdam, Netherlands, david.lai@vu.nl, Said Dabia, Yossiri Adulyasak, Guy Desaulniers

The Vehicle Routing Problem with Private Fleet & Common Carrier (VRPPC) is a generalization of the Vehicle Routing Problem in which the owner of a private fleet can either visit a customer with one of his vehicles or outsource the customer to a common carrier. This family of problems has many practical applications in the design of last mile distribution services, and has received some attention in the literature. We extend the VRPPC by considering stochastic demand and a realistic cost structure that accounts for quantity discounts on outsourcing costs. We model the problem as a two-stage stochastic program, and present an exact approach based on Benders' decomposition and branch-and-cut-and-price.

5 - Inventory Rebalancing in Bike Sharing Systems Using a Combined Clustering and Vehicle Routing Approach

Mohammad Dehghanimohammadabadi, Northeastern University, Boston, MA, United States, mdehghani@northeastern.edu, Mohit Bansal, Tong Zhang

Bike sharing systems have grown vastly over the past few years as a sustainable means of transportation. A key element for such systems is rebalancing the number of bikes using multiple vehicles with fixed capacity across the network. We present a hybrid metaheuristic algorithm that combines genetic algorithm to find the optimal number of station clusters and the number of vehicles required along with simulated annealing to minimize the distance within a cluster for each vehicle. The method was evaluated for real-world data and results are provided which illustrate the effectiveness of the hybrid algorithm in determining the most optimal route while satisfying rebalancing requirements.

■ WD41

CC- Room 610

Algorithms for Network Problems

Sponsored: Computing

Sponsored Session

Chair: Qie He, University of Minnesota, Minneapolis, MN, 55455, United States

1 - A Fast Exact Algorithm for Minimum Convex-costFlow on the Dynamic Lot Size Network

Qie He, University of Minnesota, Minneapolis, MN, 55455, United States, qhe@umn.edu, Zeyang Wu

We study a minimum convex-cost flow problem on the dynamic lot size network, which finds many applications in production planning, transportation, and resource allocation. The current best algorithm for the integer version of the problem has a time complexity of $O(n^2 \log n \log(B/n))$, where n is the total number of sink nodes in the network and B is the total demand. We develop an $O(n^2 \log(B/n))$-time algorithm for the integer version of the problem and an $O(n^2\log(B/n/\epsilon))$-time algorithm for the continuous version.

2 - A Cost Scaling Algorithm for the Minimum Average Cost Flow Problem

Dorit Simona Hochbaum, University of California-Berkeley, Berkeley, CA, United States, dhochbaum@berkeley.edu, Xu Rao

The minimum average cost flow problem (MACFP) is a network flow problem with a fixed cost for using the network as well as variable flow costs depending on the amount of flow on each arc. The objective is to minimize the total fixed and variable cost per unit of flow going from any supply node to any demand node. Previous algorithms for MACFP apply binary search on the total amount of flow, where in each iteration solving the minimum cost network flow associated with the guessed amount. . We introduce here an algorithm that solves MACFP directly utilizing cost scaling technique.

3 - Cutting Planes for Global Optimization of Water Distribution Network Design

Byron Tasseff, Scientist, Los Alamos National Laboratory, Los Alamos, NM, United States, btasseff@lanl.gov, Russell Bent, Pascal Van Hentenryck

Physical systems governed by nonlinear resistances and potential-driven flows exist in a variety of important applications, including the optimization of potable water distribution networks. This work considers water network design problems with monotonically increasing potential loss functions and discrete resistance choices. A relaxation of the potential loss constraint is first used to reformulate the design problem as a mixed-integer convex program. Cuts based on a separate novel convex system are then derived and compared with conventional no-good cuts to remove infeasible designs.

4 - Branch-and-Cut Algorithms for Steiner Tree Problems with Privacy Conflicts

Alessandro Hill, California Polytechnic State University, San Luis Obispo, CA, 93407, United States, ahill29@calpoly.edu, Stefan Voss, Roberto Baldacci

We propose two novel variants of the Steiner tree problem in graphs, motivated by applications in secure strategic telecommunication network design. The optimization models incorporate two types of privacy conflicts between pairs of conflicting terminals that affect the tree structure. We develop non-compact integer programming formulations and elaborate branch-and-cut methods. Valid inequalities are suggested that are crucial when solving these problems, and dominance relationships between the induced polyhedra are established. The cutting plane effectiveness with respect to the dual bound and the performance of the exact algorithm are assessed on SteinLib-based test instances.

■ WD42

CC- Room 611

Network optimization under uncertainty

Sponsored: Optimization/Network Optimization

Sponsored Session

Chair: Timothy Holzmann, Clemson University, Clemson, SC, 29634, United States

1 - Approximate Equitible Partitions and Synchronized Networks

David Phillips, PhD, US Naval Academy, Annapolis, MD, 21402, United States, dphillip@usna.edu

We present a model for network synchronization model well known in the dynamical systems literature. In this model, the usual graph model is complemented by a state vector at each node which updates at each time point according to a given vector field as well as interactions with adjacent nodes' state vectors. Of interest are nodes that synchronize, which means their state vectors converge under the given transition functions. For unweighted edges, the graph topology completely determines which nodes synchronize but this does not hold with respect to random perturbations. We describe a model that accounts for random perturbations and discuss limitations, implications, and associated computations.

2 - Optimal Heterogeneous Asset Location Modeling for Expected Spatiotemporal Search and Rescue Demands Using Historic Event Data

Bruce A. Cox, Assistant Professor of Operations Research, Air Force Insititute of Technology, Dayton, OH, United States, bruce.cox@afit.edu, Zachary Hornberger, Brian J. Lunday

The USCG is charged w/search & rescue in maritime regions. Given the size of the Pacific & limited resources, the service seeks to posture itself to reduce expected response time. Leveraging historic records, we propose & demonstrate a two-stage approach. 1st stage: We develop & apply a stochastic zonal distribution model to evaluate spatiotemporal trends for emergency events & associated responses. 2nd stage: These results enable parameterization & solution of a MIP to ID the best locations to station limited assets. Our models ID basing strategies that yield a 9-18% increase in coverage over current basing using existing locations & 57-67% increase when considering a larger set of basing locations.

3 - Coverage-based Destruction Algorithms for Reliability Evaluation of a Wireless Sensor Network

Nicholas Boardman, University of Arkansas, Fayetteville, AR, United States, Kelly Sullivan

Wireless sensor networks (WSNs) consist of a set of sensors, distributed over a region, that monitor and report conditions out of the network. One important design consideration is the WSN's reliability of region coverage as sensors fail over time. Monte Carlo methods for WSN reliability evaluation give rise to a "network destruction" (ND) optimization problem that determines the instant of network failure given fixed sensor failure times. We propose an algorithm to solve the ND problem for coverage reliability, analyze the algorithm's complexity, and compare its theoretical and empirical performance to logical alternative algorithms.

4 - The Shortest Path Interdiction Problem with Randomized Interdiction Strategies

Timothy Holzmann, Clemson University, Engineering, Computing and Applied Sciences, Riggs Hall, Clemson, SC, 29634, United States, Cole Smith

In this Shortest Path Interdiction Problem variant, the leader's selects a probability distribution for randomized interdiction actions. The follower knows this distribution (but not the realization) and seeks to minimize the shortest expected-cost path. The leader seeks to maximize the follower's objective. Our problem is relevant to problems such as border control, where the leader's may reasonably randomize the interdiction resource. We present the complexity of this problem, and several algorithms for various assumptions on the cost functions. We examine the efficacy of our algorithms on a test bed of randomly generated instances.

■ WD43

CC- Room 612

Optimization Approaches for real-world routing and Transportation Problems

Sponsored: Computing

Sponsored Session

Chair: Kyle Booth, University of Toronto, University of Toronto, Toronto, ON, M8W 2N6, Canada

1 - The Social Robot Routing Problem

Kyle Booth, University of Toronto, Toronto, ON, M8W 2N6, Canada, kyle.booth@mail.utoronto.ca

The variety of tasks that social robots are being designed to complete is rapidly expanding and the constraints on their coordination becoming increasingly complex. We introduce the social robot routing problem (SRRP), an extension of vehicle routing that focuses on the constraints associated with routing teams of heterogeneous social robots in human-populated environments. We present mixed-integer linear programming (MILP) and constraint programming (CP) approaches for the SRRP, designed to optimize routes for teams of social robots. The proposed models synthesize ideas from electric vehicle routing with time windows and vehicle routing with multiple synchronization constraints.

2 - Optimizing Surveillance Routes for a Team of Robots: Solving the Graph-clear Problem

Michael Morin, Université Laval, 201-1381 rue de Jupiter, Québec, QC, G6W 8H9, Canada, Kyle Booth, Margarita Paz Castro, Tony T. Tran, Chang Liu, Chris Beck

We develop optimization approaches to the graph-clear problem, a pursuit-evasion problem where mobile robots must clear a facility of intruders. The objective is to minimize the number of robots required to execute a surveillance operation ensuring no intruder can escape the facility without being noticed. In this talk, we discuss the formal problem, its applications as well as state-of-the-art solving techniques based on the model-and-solve framework. Finally, we give insights on recent formal and empirical results on that problem.

3 - Real-time Ride Sharing Systems

Pascal Van Hentenryck, Georgia Institute of Technology, Atlanta, GA, 30332, United States, Connor Riley, Antoine Legrain

This presentation considers real-time dispatching for large-scale ride-sharing services over a rolling horizon. It presents RTDARS which relies on a column-generation algorithm to minimize wait times while guaranteeing short travel times and service for each customer. Experiments using historic taxi trips in New York City for instances with up to 30,000 requests per hour indicate that the algorithm scales well and provides a principled and effective way to support large-scale ride-sharing services in dense cities.

4 - Solving the Minimum Travel Time Problem Using Dynamic Discretization Discovery

Edward Yuhang He, PhD, Georgia Institute of Technology, Atlanta, GA, United States, edwardhe@gatech.edu, Natashia Boland, Martin Savelsbergh, George L. Nemhauser

Finding a shortest path in a network is a fundamental optimization problem. We focus on the settings in which the travel time on arcs depends on the starting time of traversal. In such settings, reaching the sink as early as possible is not the only objective of interest. If waiting is allowed, minimizing the travel time along a path can be important. We start with a constructive proof that the ``Minimum Travel Time Problem" can be solved in polynomial time. The approach is then refined using the ideas of Dynamic Discretization Discovery, which we show to be effective using our computational results. Finally, we conclude with new complexity results for a large class of time-dependent shortest path problems.

5 - A Study on the Traveling Salesman Problem with a Drone

Ziye Tang, Carnegie Mellon University, Pittsburgh, PA, United States, Willem-Jan Van Hoeve, Paul Shaw

A promising new model for future logistics networks integrates trucks with drones. The drone can pick up packages from the truck and deliver them by air while the truck is serving other customers. In this work, we consider the scenario of a single truck and one drone, with the objective to minimize the makespan. Strong NP-hardness is shown even when the truck route is given. We then present a compact constraint programming formulation. Experiments show solving CP to optimality is significantly faster than the state-of-the-art exact algorithm. For larger instances, our CP-based heuristic algorithm is competitive with a state-of-the-art heuristic method.

■ WD44

CC- Room 613

Joint Session ICS/DM: Optimization in Machine Learning IV

Sponsored: Computing

Sponsored Session

Chair: John W. Chinneck, Carleton University, Ottawa, ON, K1S 5B6, Canada

1 - Applying a Classifier to Solve Mixed Integer Quadratic Problems in CPLEX

Pierre Bonami, IBM, Calle del Plomo 18, Esc 2, Piso 3, Puerta C, Madrid, 28045, Spain, pierre.bonami@es.ibm.com, Giulia Zarpellon, Andrea Lodi

Within state-of-the-art optimization solvers such as IBM-CPLEX the ability to solve both convex and nonconvex Mixed-Integer Quadratic Programming (MIQP) problems to proven optimality goes back few years, but still presents unclear aspects. We are interested in understanding whether for solving an MIQP problem it is favorable to linearize its quadratic part or not. Our approach employs Machine Learning techniques to learn a classifier that predicts, for a given MIQP instance, the most suitable resolution method within IBM-CPLEX's algorithmic framework.

2 - On Using the P-median Problem for Clustering with Feature Selection

Juan Antonio Orozco Guzman, Sr. Data Scientist, Gurobi, Guadalajara, Mexico

Recently, a mixed-integer linear program was introduced to perform clustering and feature selection simultaneously. This model is in fact an extension of the radius formulation for the p-median problem, where the distance between objects is calculated by only considering the q most important features. We present an alternative model that uses patterns rather than the usual cumulative decision variables, allowing for a much sparser structure, which can also be applied to the classic p-median problem.

Keywords: Unsupervised learning, clustering, feature selection, mixed-integer linear programming, p-median problem, radius formulation.

3 - Sparse Robust Regression with Continuous Exact K-sparse Penalties

Jun-ya Gotoh, Chuo University, 1-13-27 Kasuga, Bunkyo-ku, Tokyo, 112-8551, Japan, jgoto@indsys.chuo-u.ac.jp, Shummin Nakayama

In this talk we study applications and efficient algorithms for k-sparse recovery problem on the basis of the Continuous Exact k-Sparse Penalties (CXPs) or which is also known as partial regularizers. Each CXP is defined by a non-convex but continuous function and the equality forcing the function value to be zero is known to be equivalent to the k-sparse constraint defined with the so-called l0-norm. Algorithms based on the proximal mapping of the lp-norm based CXPs will be examined for sparsity-seeking estimation problems such as a sparse robust.regression problem.

4 - Inferring Optima from Random Forests: An Empirical Approach

Haris Krijestorac, University of Texas-Austin, Austin, TX, 78705, United States, haris.krijestorac@utexas.edu

Although non-linear models may facilitate feature selection and improve predictive accuracy, a drawback of such models is their lack of interpretability. To address this limitation, we propose a data mining approach to strategically unpack the "black box" of random forest classification by inferring optimal values associated with model features. Our approach is based on gradient search within strategic neighborhoods, coupled with k-nearest-neighbors. We demonstrate the accuracy of our method across feature spaces of varying dimensionality, as well as varying data size and sparsity. Our approach can be especially useful in identifying feature spaces that are beneficial, yet under-explored.

■ WD45

CC- Room 614

Nonlinear Optimization with Applications in Machine Learning

Sponsored: Optimization/Nonlinear Programming

Sponsored Session

Chair: Digvijay Pravin Boob

1 - An Accelerated Proximal Point Method for Solving Nonconvex-Concave Min-max Problems

Weiwei Kong, Georgia Institute of Technology, Atlanta, GA, 30318, United States, wwkong92@gmail.com, Renato D.C. Monteiro

An emerging problem of interest within the area of nonconvex optimization is the (possibly nonconvex-nonconcave) nonlinear min-max problem. In this talk, we present an efficient inexact proximal-point algorithm for solving a class of nonconvex-concave min-max problems under various termination conditions. An extension to a linearly-constrained variant of these problems is also discussed.

2 - Distributed Optimization under Communication Constraints

Thinh Doan, Georgia Institute of Technology, Atlanta, GA, 30332, United States, thinhdoan@gatech.edu

We study distributed optimization problems over a network when the communication between the nodes is constrained, and so information exchanged over the network must be quantized. Our main contribution is to propose a novel adaptive quantization method, where the main idea is to quantize the nodes' estimates based on the progress of the algorithm. We then derive the bounds on the rates of the proposed method as a function of the bandwidths. Our results show that using the adaptive quantization, the rates of distributed gradient methods are unaffected by finite bandwidths. Our results achieve the optimal rates of distributed gradient methods under finite bandwidths.

3 - Proximal Point Method for Optimization with Nonconvex Functional Constraints

Digvijay Boob, Georgia Institute of Technology, NW, Atlanta, GA, 30332, United States, digvijaybb40@gatech.edu, Guanghui Lan, Qi Deng

In this work, we pose a new proximal point method for nonconvex (possibly nonsmooth) program with nonconvex constraints which has applications in risk averse ML and robust optimization. We show our algorithm converges to a t-KKT point in O(1/t) iterations under a famous constraint qualification. We show same convergence rates when the subproblem in each iteration is solved approximately. We propose an accelerated (stochastic) dual method converging to a t-approx solution of the subproblem in O(1/t^(0.5)) or O(1/t) iterations for strongly convex deterministic or stochastic problem, respectively. This seems to be the first work applying proximal point method for this class of nonconvex problem.

4 - A Doubly Accelerated Inexact Proximal Point Method for Nonconvex Composite Optimization Problems

Jiaming Liang, Georgia Institute of Technology, Atlanta, GA, United States, Renato D. C. Monteiro

We describe and establish the iteration-complexity of a doubly accelerated inexact proximal point (DAIPP) method for solving the nonconvex composite minimization problem whose objective function is f + h where f is a (possibly nonconvex) differentiable function whose gradient is Lipschitz continuous and h is a closed convex function with bounded domain. DAIPP performs both outer and inner iterations. Its outer iterations correspond to the ones of the accelerated inexact proximal point scheme. Its inner iterations are the ones performed by an accelerated composite gradient method for inexactly solving the convex proximal subproblems generated during the outer iterations.

■ WD46

CC- Room 615

Optimization and Control Models for Connected and Automated Vehicles

Sponsored: Transportation Science & Logistics/Intelligent Transportation Systems (ITS)

Sponsored Session

Chair: Kuilin Zhang, Michigan Technological University, Houghton, MI, 49931, United States

1 - Safe Stopping Distance for Autonomous Intersection Management

Di Kang, University of Minnesota, Minneapolis, MN, 55455, United States, kang0275@umn.edu, Michael Levin

Previous studies have proposed signal-free autonomous intersection management (AIM) which uses connected vehicle communications and precision of automated systems to plan and follow collision-free trajectories. However, safety during abnormal conditions (such as a vehicle malfunction) within AIM has received little attention. Building on a conflict-point optimization model of AIM, we add buffers and develop a response protocol to avoid collision when a vehicle malfunctions. We present a mixed integer linear program and investigate the effects of these safety buffers on efficiency.

2 - Simlite: An Open Modeling Framework for Integrated Traffic Flow Simulation and Optimization

Jiawei Lu, Arizona State University, Tempe, AZ, 85281, United States, jiaweil9@asu.edu, Xuesong Zhou

The emergence of connected and autonomous vehicle (CAV) makes it possible to coordinate the motion of vehicles in a cooperative way. We introduce SIMLite here to provide an open modeling framework for integrated traffic simulation and optimization, especially in a CAV environment. We will discuss a CA(M)-based traffic flow model for vehicle motion simulation and a mixed integer linear programming (MILP)-based vehicle trajectory optimization model.

3 - Integrated Control of Traffic Signals and Vehicle Trajectories

Jiaqi Ma, University of Cincinnati, Cincinnati, OH, United States, jiaqi.ma@uc.edu

Connected and automated vehicle (CAV) technologies offer promising solutions for challenges facing our transportation systems. Vehicle trajectory control and traffic signal control based on CAV technologies are two approaches that have great potential and should be integrated into a single process such that both aspects can be optimized to achieve maximum benefits. This paper proposes an efficient algorithm, based on dynamic programming and an acelerated trajectory construction and evaluation method, for the integrated optimization problem that can simultaneously optimize the trajectories of CAVs and signal timing and phasing of traffic signal controllers.

4 - A Data-driven Optimization Based Cooperative Connected and Automated Driving Model

Kuilin Zhang, Michigan Technological University, Civil and Environmental Engineering, 870 Dow Environmental Sciences, Houghton, MI, 49931, United States, klzhang@mtu.edu

We propose a data-driven optimization based online predictive cooperative connected and automated driving control model using real-time high-frequency connected vehicle data via vehicle-to-vehicle communication technologies. An online real-time learning algorithm is used to predict the immediate preceding vehicle driving dynamics using streaming sensing data based on the concept of forecasting the forecasts of others. The predicted driving dynamics will be integrated into a data-driven optimization based model predictive control model for a robust cooperative adaptive cruise control model of a fleet of connected and automated vehicles.

5 - A Game-theoretic Framework for Autonomous Vehicle Velocity Control

Zhaobin Mo, Columbia University, New York, NY, United States, Sharon Di, Kuang Huang, Qiang Du

A transportation system with fully autonomous vehicles can be modeled as a multi-agent system, where autonomous vehicles interact with one another through coupled optimal driving strategies. However, the existing literature on autonomous vehicle longitudinal control suffers from scalability issues. This study tackles such a challenge by employing mean field approximation and deriving a macroscopic game-theoretic framework for autonomous vehicles traffic flow from microscopic velocity control. The developed game is mean field game (MFG), which is essentially the limiting differential game with an infinite number of agents.

■ WD47

CC- Room 616

Transportation, Public I

Contributed Session

Chair: Charalampos Sipetas, University of Massachusetts Amherst

1 - A New Look at the Hyperpath-based Algorithms for Transit Assignment Problems

Zhandong Xu, Southwest Jiaotong University, Chengdu, China, Jun Xie, Xiaobo Liu

Compared to the traffic assignment problem (TAP) in a highway network, the transit equilibrium assignment problem (TEAP) is much less studied, especially in terms of solution algorithms. This paper proposes two Newton-type hyperpath-based algorithms for a frequency-based TEAP. These newly developed algorithms, as well as two benchmark algorithms from the literature, are tested and compared on two real-world transit networks, in addition to a number of randomly generated grid networks. The results show the proposed hyperpath-based algorithms significantly outperform the benchmark algorithms in large networks.

2 - Fast-charging Station Deployment for Battery Electric Bus Systems Considering Electricity Demand Charges

Ziqi Song, Assistant Professor, Utah State University, Logan, UT, United States, ziqi.song@usu.edu, Yi He, Zhaocai Liu

Fast charging battery electric bus system is getting popular in recent years. However, fast charging may result in high electricity demand charges. In this study, a mixed integer linear program that minimizes the total costs of a battery electric bus system, including battery costs, fast charging station costs, demand charges, and ESS costs, is proposed to locate the fast charging stations and determine whether to install ESS as well as design the battery size for the electric buses simultaneously. Numerical studies are provided to demonstrate the effectiveness of the proposed model.

3 - Reexaming Rail Transit's Comparative Advantages in Travel Time and Cost Over Taxis: An Empirical Analysis of Washington, D.C. and Chicago

Sajeeb Kumar Kirtonia, Research Assistant, Florida State University, Talahassee, FL, United States, sajeeb.kumar.kirtonia@gmail.com, Yanshuo Sun

Due to its flexibility, taxi is a desirable transportation means for urban travelers, while rail transit characterized by its dedicated right-of-way could be more reliable, or even faster. The taxi trip data in the public domain provide an unprecedented opportunity to investigate the taxi performance in the urban environment. Most rail transit schedules and fares are also publicly available. Thus, this study compares rail transit and taxi in terms of travel time and cost, based on the real-world taxi trip data in Washington, D.C., and Chicago.

4 - Economic Analysis of On-route Fast Charging for Battery Electric Buses: Case Study in Utah

Zhaocai Liu, Utah State University, Logan, UT, United States, zhaocai.liu@aggiemail.usu.edu, Ziqi Song, Yi He

This study conducts a quantitative economic analysis of on-route fast charging for battery electric buses, thereby providing some guidelines for transit agencies. An integrated optimization model is first proposed to determine battery size, charger type, and recharging schedule for a general battery electric bus route. Based on the model, an economic analysis of on-route fast charging is then performed on ten real-world bus routes and a simplified general bus route with different parameters. A sensitivity analysis is also conducted to show the impact of potential price reductions of batteries.

5 - Data-driven Origin-destination Matrix Estimation in Large-scale Integrated Transport Systems

Jorge Huertas, Universidad de los Andes, Bogotá, Colombia, huertas.ja@uniandes.edu.co, Sergio Cabrales, Carolina Osorio, Andres L. Medaglia, Marcelo Botero, Alejandro Palacio

The OD matrix estimation problem is at the core of decision making for transport operators all around the world. Integrated transport systems that interoperate various services are common in big cities in Latin America. Bogotá's integrated transport system consists of two articulated components; a BRT system and a bus system that supply approximately 60% and 40% of public transport demand respectively. We propose a methodology for calculating an OD matrix for the bus service incorporating information from diverse sources. This information is collected from smart-cards transactions, bus geolocalization, mobility surveys and OD matrix estimations for other means of transport.

6 - Optimization of Paratransit Service with TNCs

Charalampos Sipetas, PhD Student, University of Massachusetts Amherst, Amherst, MA, United States, Eric J. Gonzales

A methodology is proposed to optimize Boston's paratransit system in coordination with a Transportation Network Company (TNC). Daily routes are constructed with a greedy algorithm. The position of each trip in the route determines the marginal cost by contributing to required fleet, vehicle hours, and vehicle miles of operation. These costs are compared with TNC fares for the same trips. The main output is a set of trips that, if assigned to a TNCs, leads to minimum combined costs for paratransit and TNCs. The algorithm accounts for the set of trips that cannot be assigned to TNCs for various reasons.

■ WD48

CC- Room 617

Advances in Traffic Information and Vehicle Platooning

Sponsored: Transportation Science & Logistics/Intelligent Transportation Systems (ITS)

Sponsored Session

Chair: Neda Masoud, University of Michigan, Ann, MI, 48109, United States

1 - Two-stream Multi-channel Convolutional Neural Network for Multi-lane Traffic Speed Prediction Considering Volume Impact

Ruimin Ke, University of Washington, Seattle, WA, United States, ker27@uw.edu, Wan Li, Zhiyong Cui, Yinhai Wang

Existing traffic speed prediction studies have two major limitations. First, they predict aggregated traffic speed rather than lane-level speed; second, most studies ignore the impact of other traffic flow parameters in speed prediction. To address the issues, we propose a novel model for multi-lane traffic speed prediction considering volume impact. In this model, we first introduce a new data conversion method that converts raw traffic data into spatial-temporal multi-channel matrices. Then we carefully design a two-stream convolutional neural network to effectively learn the features in multiple dimensions. Accordingly, a new loss function is developed.

2 - Itinerary Planning for Cooperative Truck Platooning: Exact Methods and Approximation Algorithms:

Mojtaba Abdolmaleki, University of Michigan, Ann Arbor, MI, United States, mojtabaa@umich.edu, Mehrdad Shahabi, Yafeng Yin, Neda Masoud

A cooperative truck platoon is a set of virtually linked trucks driving with a small intra-vehicle gap. Truck platooning yields several benefits but this talk focuses on scheduling travel itineraries of a given set of trucks to maximize platooning opportunities to save energy. We formulate the problem as a concave minimum cost flow problem and devise solution algorithms to find the optimal formation for medium to large size fleet. Finally, a fast approximation algorithm with guaranteed performance is proposed and tested.

3 - Optimization of Coordinated Platooning for Heavy-duty Vehicles

Xi Xiong, New York University, New York, NY, United States, xi.xiong@nyu.edu, Li Jin

Platooning of heavy-duty vehicles (HDVs) has the potential for remarkable efficiency and environmental benefits. In this paper, we study the coordination of HDV platooning on a highway section. Multiple HDVs are merged into one platoon based on between-HDV headways. The merging is done by accelerating the following vehicles to catch up with the leading ones. We study the optimal set of headways to determine the platooning coordination that leads to minimal fuel consumption in deterministic and stochastic scenarios. We also compare our results with that from Simulation of Urban MObility (SUMO).

4 - Adaptive Information Dissemination Strategy in a Vehicle-to-Vehicle Communication System by Considering Service Differentiation

Yangjiao Chen, Georgia Institute of Technology, Atlanta, GA, United States, Srinivas Peeta

This study develops a dynamic adaptive scheme to ensure the optimal utilization of available communication resources to maximize spatiotemporal coverage of information based on different service requirements and communication reliability. Transmission power and the number of multicast receivers are adapted by factoring frequently changing network topology and traffic characteristics. Numerical experiments demonstrate the effectiveness of the proposed model under different traffic conditions.

■ WD49

CC- Room 618

Facilities Planning and Project Management

Contributed Session

Chair: Benhur Satir, Cankaya University, Industrial Engineering Department, Eskisehir Yolu 29. Km Yenimahalle, Ankara, 06810, Turkey

1 - Rack Design for 3D AS/RS Considering the Equipment's Speed Profile

Wenquan Dong, University of Tennessee, Knoxville, TN, United States, dwenquan@vols.utk.edu, Mingzhou Jin

In this study, we consider the optimal rack dimension problem for crane-based 3D automated storage and retrieval systems (AS/RS) with shuttle-based depth movement systems (DMMs) under random storage policy. The system consists of shuttles taking care of depth movement of SKUs in the rack and an automated crane moving SKUs along the horizontal and vertical direction. If the number of shuttles is less than lanes, the crane is also responsible for moving shuttles across lanes. The objective of this study is to analyze the impact of rack dimensions and equipment's speed on system performance and find the optimal dimension of the system under a given speed profile.

2 - See the Light: Optimization of Put-to-light Order Picking Systems

Konrad Stephan, Friedrich Schiller University-Jena, Jena, Germany, Nils Boysen, David Füßler

Put-to-light (P2L) order picking inverts the basic logic of conventional picker-to-parts systems. Instead of successively visiting the storage positions of stock keeping units (SKUs) when picking an order, an order picker accompanies successive bins each containing multiple items of a SKU. When the picker passes an order requiring the current SKU he puts the requested items into the associated order bin. This talk evaluates 4 different setups of P2L systems, which require the solution of different storage assignment and SKU sequencing problems during operations. We state the problems, prove computational complexity, provide solution algorithms and benchmark the impact on picking performance.

3 - Cloud-enabled Platform for Service Assignment and Control in Equipment Maintenance

yu chen, The University of Hong Kong, hong kong, Hong Kong

This research is one of the earliest studies to systematically propose the concept of real-time cloud equipment maintenance service (CEMS). CEMS is an important part of equipment maintenance services. It implements and controls real-time information and maintenance task allocation control of equipment to meet the requirements of maintenance service operators and equipment users. The aim of the research is to promote the characteristics of CEMS through real-life industrial cases and develop practical methods to improve CEMS efficiency in the daily equipment operations.

4 - Profit Allocation and Subsidy Mechanism for Public-Private Partnership Toll Road Projects

Lulu Jin, Dalian University of Technology, Dalian, China, jinlulu1226@126.COM

Public-Private Partnership (PPP) toll road projects are widespread around the world. However, it is difficult to predict traffic demand and cost accurately, which may lead to high profit risks for the private sector or bump up the fiscal burden for the government. This paper proposes an effective framework for the probabilistic evaluation of the excess profit allocation between the government and the private sector, as well as the subsidy mechanism. It aims to provide a knowledge base so that the decision makers can recognize the importance of accurately forecasting profit risks to provide a reasonable and fair profit redistribution mechanism to facilitate PPP contract design.

5 - Confidence Regions in Wasserstein Distributionally Robust Estimators

Jose Blanchet, Stanford University, Stanford, CA, United States, Nian Si, Karthyek Murthy

Wasserstein distributionally robust optimization (DRO) estimators are obtained as the solution of a min-max problem in which the statistician selects a parameter minimizing the worst-case loss among all probability models within a certain distance from the underlying empirical measure. In addition to producing estimators endowed with enhanced robustness properties, Wasserstein DRO estimators recover as a particular case a wide range of regularized estimators, including LASSO and support vector machines. This paper studies the asymptotic normality of underlying DRO estimators as well as the properties of an optimal confidence region induced by the Wasserstein DRO formulation.

6 - A Physical Ergonomic Compatibility Analysis of the Classroom Furniture

Benhur Satir, Cankaya University, Ankara, Turkey, benhur@cankaya.edu.tr, Filiz Erdo an Çelikçi

In this study, the classroom furniture that the Turkish students within10-14 years-old range use is assessed. It is aimed to understand whether using the same furniture over 4 year education period causes ergonomic discomfort and take necessary precautions if it exists. For this purpose, Maltepe Primary School is selected to conduct the study, which is one of the largest schools in Ankara, under the control of Ministry of Education. 119 students are selected as the sample and six anthropometric measures are taken on each student. Fitness tests are performed between classroom furniture dimensions and anthropometric measures using SPSS software. In the analyses, high level of mismatch is observed.

■ WD50

CC- Room 619

Network Optimization and Freight Transportation

Contributed Session

Chair: Masoud Barah, University of Tennessee, Knoxville, TN, 37996-2315, United States

1 - Inventory Repositioning via Price Optimization

Hoda Sabeti, Hertz, Naples, FL, 34119, United States, Montgomery Blair, Anirudha Kulkarni, Kevin Yeh

Rental car industry offers a range of products. Of all the products offered, intercity product is particularly important as it not only generates revenue but also moves cars without the use of shuttles. As part of intercity initiatives, we present different approaches to use intercity products for inventory repositioning based on value of a car in different cities. Results show reduction of shortage of inventory and improvement in overall revenue.

2 - A Time-expanded Formulation for the Locomotive Routing Problem with Maintenance Considerations

Pedro Miranda, HEC Montreal, Montreal, QC, Canada, pedro.miranda@hec.ca, Jean-François Cordeau, Emma Frejinger

In this talk we address the Locomotive Routing Problem (LRP), a large-scale optimization problem faced by railroad companies that aims to determine the optimal sequence of trains each locomotive is assigned to, while considering locomotives maintenance requirements over the planning horizon. A mixed integer formulation, based on a time-expanded network, and computational results are presented.

3 - Hub Location with Heterogeneous Economies of Scale

Masoud Chitsaz, Element AI, Montreal, QC, Canada, masoud.chitsaz@elementai.com, Borzou Rostami, Okan Arslan, Gilbert Laporte, Andrea Lodi

We study the single allocation hub location problem with heterogeneous economies of scale in which the hub-hub connection costs are piecewise linear functions of flow volume. We model the problem as a mixed integer linear program (MILP) and also a quadratically constrained linear program (QCLP). We use an integer L-shaped decomposition to solve the MILP formulation. We dualize a set of complicating constraints to generate a Lagrangian function to solve QCLP. We perform extensive computational experiments on both uncapacitated and capacitated large-scale problem instances. The results indicate the efficacy of our solution methods.

4 - An Optimization Tool for Rail Road Intermodal Transportation Network System

Fereydoun Adbesh, J.B. Hunt Transport Inc, Lowell, AR, United States, fereydoun.adbesh@jbhunt.com, Douglas Mettenburg

This research propose an optimization tool to analyze the rail road intermodal network for decision makers. The tool has two main purposes: i) identify the most beneficial shipments in the network and ii) analyze the network under different scenarios. A new periodic intermodal freight selection model during specified time periods is developed and formulated as a mixed integer program. The model selects the shipments that maximize the total profit while minimizing the total cost of empty movements in the network in each period. Empty movements on either road or rail is mostly because of imbalances between the number of pickups and deliveries in the ramp areas. Optimal solutions are found using CPLEX 12.8

5 - Designing an Efficient Exact Solution Approach to the Time-discretized Job Shop Scheduling Problem

Masoud Barah, Post-doctoral Research Fellow, Northwestern University, Evanston, IL, United States, mbarah@northwestern.edu, Jim Ostrowski

This research investigates a condition for which the polyhedron of the job shop scheduling problem is Integral. This condition is then used to construct an efficient solution approach. Specifically, by exploiting the problem integrality condition, we present a novel branching and pruning strategy in the branch and bound tree. The solution approach is boosted with a heuristic that sequentially solves a series of linear programming models to enhance the incumbent solutions. Computational experiments show that the developed solution approach can efficiently solve benchmark job shop and flow shop problems to optimality.

■ WD51

CC- Room 620

Joint Session AAS/TSL Air: Data Science for Air Transport Optimization

Sponsored: Aviation Applications

Sponsored Session

Chair: Xiaoqian Sun

1 - Estimating Airport Ground Transport Mode Choice Using Market Aggregate Data

Wenyi Xia, University of British Columbia, Vancouver, BC, Canada

We propose an empirical approach to estimate air travelers' airport ground transport mode choice using aggregate data. We match the flow of airport passengers with the ridership of airport ground transport modes. This approach is applied to Incheon International Airport (ICN). We show that passengers incur higher disutility from schedule delay than travel time. We also find that passengers flying low-cost airlines are more likely to take public transportation. We estimate how ridership of airport ground transport would be if the schedules were adjusted. We find that the existing schedules at ICN are suboptimal and could be substantially improved to achieve higher ridership.

2 - Characterizing Economic Outcomes Using Satellite Data for Transport Development

Weizun Zhao, City University of Hong Kong, Hong Kong, wzzhao6-c@my.cityu.edu.hk, Lishuai Li

Nighttime lighting satellite data are proven to be a good proxy for economic well-being, i.e. Gross Domestic Product (GDP). However, most methods are based on traditional regression analysis and the prediction accuracy is limited. We aim to develop a new method based on deep learning to predict GDP using nighttime light data and daytime image date from satellite. Since the data are publicly available, we can measure growth of sub regions instead of using countries as the unit of analysis and obtain a more detailed distribution of GDP in a region. We may further combine the satellite data with GIS data to analyze the impact of transport development in a region.

3 - Airline Network Design Problem with the Consideration of Demand Price Relationship

Liang Zhe, Tongji University, Shanghai, China

In the traditional airline network design, airlines first estimate the demand and price of each flight based on the market share and the historical data. This demand and price information is used by the fleet assignment problem as the input constant. In our research, instead of consider the demand and price as the constants, we use a piece-wise linear function to describe the demand and price relationship. We formulate the fleet assignment problem as a quadratic problem and propose an efficient heuristic to solve it.

4 - Data Mining over ADS-B Trajectories

Sebastian Wandelt, Beihang University, Beijing, China

With ADS-B, Automatic Dependent Surveillance-Broadcast, aircraft determine their positions based on satellite technology; their broadcasted signals are being received, decoded and merged by receiver networks around the globe. This presentation gives an overview on the data management challenges coming with data science analysis of trajectories and provides prototypical solutions which scale up to planet scale data. Previously-unseen in-depth analysis of global flight patterns leads to the derivation of novel prediction models and, in turn, to safer and more efficient aviation.

5 - Impact of HSR on Aviation in Europe and China

Pengfei Yi, Beihang University, Beijing, China

Research on competition and cooperation between high-speed rail (HSR) and air transportation is usually limited to single city pairs or inside smaller regions, induced by either lack of data or lack of computational resources. We aim to build a generic model for traffic connectivity at continental scale. Multiple globally available datasets, including OpenStreetMap, GPWv4, and other socioeconomic data, are joined, cleansed, and fitted. Actual railway and airline schedule data is used to verify the effectiveness of the model. An emphasis is put on the impact of HSR on aviation.

■ WD52

CC- Skagit 1

Joint Session RMP/Practice Curated: Forecasting Methods and Analysis in Practice

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Manu Chaudhary, PROS, Houston, TX, 77054, United States

1 - Forecasting Hotel Reservations Using Deep Learning

Jian Wang, RealPage, Alpharetta, GA, 30022, United States, Jian.Wang@RealPage.com

In this talk, we review three methods commonly used to forecast hotel reservations, and then propose two long short-term memory (LSTM) models based on recurrent neural networks. To measure the relative performance, we estimate the two LSTM models as well as six machine learning (ML) models against actual reservations of four hotels. The empirical results show that, on average, the forecasting accuracy of using LSTM models has been improved about 3.0% over that of using the best of the six ML models.

2 - Forecasting Improvement with Short-term Adjustment and Long-term Stability

Chih-Hsien Wu, PROS, Houston, TX, United States, Ross Winegar

A common practice to forecast booking behavior is to use time-series with a time-weighting parameter to control how forecasts adjust over time as new data is observed. This can produce the unintended consequence of data having outsized impacts between seasons - e.g. a drop in bookings in February affects summer peak forecasts in July. A proposed solution is to ensemble together forecasts using different drift learning rates, so that changes in bookings are reflected in near-term departures while maintaining stability for longer-term departures.

3 - Analyzing Hierarchical Forecasts

Manu Chaudhary, PROS, Sugar Land, TX, United States, Jiabing Li

Forecasts for a typical Revenue Management system are generated for a combination of multiple dimensions, which could lead to millions of forecast entities because of which users typically analyze the forecast results at a higher level of dimensionality. However, in doing so they lose resolution of the lowest level forecast and it can difficult to understand the reasons behind the different forecast patterns. We propose metrics and workflow to analyze the low level forecasts to guide the user to the reasons which lead to the forecast numbers different than their expectation.

4 - Unconstrained Demand Forecasting and Accuracy Assessment for Car Rental

Jordan Cuevas, Sr Data Scientist, Hertz, Estero, FL, United States

Forecasting future demand when historic observations are censored due to supply limits is an important problem in the hospitality industry, particularly in the car rental space where the fleet size can be increased relatively quickly. Here we present two approaches to forecast unconstrained demand, along with some results showing their robustness and accuracy.

■ WD53

CC- Skagit 2

Joint Session RMP/Practice Curated: Matching Platforms for Services

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Peng Shi, University of Southern California, Los Angeles, CA, 90064, United States

1 - Dog Eat Dog: Measuring Returns to Scale Using a Digital Platform Merger

Chiara Farronato, Harvard Business School, Boston, MA, United States, Andrey Fradkin

In this project, we use transaction-level data to study a merger between the two largest US-based digital platforms for overnight dog-sitting. This merger provides an opportunity to study the returns to consolidation in digital marketplaces and to measure the mechanisms underlying these returns. An advantage of our setting is that the market for dog-sitting is highly local and that the diffusion of the two platforms varied across geographies. Consequently, the merger affected different locations to a varying extent. We use an event study approach to show how the merger affected the volume of transactions as well as their quality.

2 - Random versus Directed Search for Scarce Resources

Teddy Mekonnen, PhD, Brown University, Providence, RI, United States, mekonnen@brown.edu

This paper studies how different search protocols affect social welfare in a search market with scarcity. Agents search for objects that differ in quality either through a random or a directed search protocol. Random search protocol, in which agents are randomly paired to an object of any quality, gives rise to adversely selected markets. Directed search protocol, in which agents choose with which quality types to pair, gives rise to congestion. When utility is either non-transferable or transferable through Nash bargaining, I show that random search dominates directed search in terms of welfare, even though each agent would prefer to be able to direct her search.

3 - Cream Skimming and Information Design in Matching Markets

Alex Smolin, Toulouse School of Economics, 104 Nicoll Street, Toulouse, 06511, France, alexey.v.smolin@gmail.com, Gleb Romanyuk

Short-lived buyers arrive to a platform over time and randomly match with sellers. The sellers stay at the platform and decide whether to accept incoming requests. The platform designs what buyer information the sellers observe before deciding to form a match. We show full information disclosure leads to a market failure because of excessive rejections by the sellers. If sellers are homogeneous, then coarse information policies are able to restore efficiency. If sellers are heterogeneous, then simple censorship policies are often constrained efficient as shown by a method of calculus of variations.

4 - Consumer Protection in an Online World: An Analysis of Occupational Licensing

Chiara Farronato, Harvard Business School, Soldiers Field Road, Boston, MA, 02163, United States, Andrey Fradkin, Brad Larsen, Erik Brynjolfsson

We study the effects of occupational licensing on consumer choices and market outcomes in a large online platform for home services. We exploit exogenous variation in the time at which licenses are displayed on the platform to identify the causal effects of licensing information on consumer choices. We find that licensing status is not valued by consumers and corroborate this finding in a survey of consumers. Next, we use variation in licensing stringency across states and occupations to measure the effect of licensing on the market equilibrium. We find that more stringent licensing leads to less competition and higher prices, but does not improve customer satisfaction.

■ WD54

CC- Skagit 3

Pricing and Assortment Problems in E-commerce

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Jacob Feldman, Olin Business School, Saint Louis, MO, 63108-1291, United States

1 - Click-based MNL: Algorithmic Frameworks for Modeling Click Data in Assortment Optimization

Ali Aouad, London Business School, London, NW64TG, United Kingdom, aaouad@london.edu, Jacob Feldman, Danny Segev, Dennis Zhang

We introduce the click-based MNL choice model, a novel framework for capturing the customers' purchasing behavior in e-commerce settings. In this setting, we assume that the click behavior within product recommendation or search results pages provides an exact signal regarding the alternatives considered by the customers. Our main algorithmic contribution comes in the form of a polynomial-time approximation scheme (PTAS) for the resulting assortment optimization problem. Using data from a large online retailer, we quantify the benefits of incorporating click behavior within choice models.

2 - Multi-product Price Optimization under a General Cascade Click Model

Huanan Zhang, Penn State University, State College, PA, 16803, United States, huz157@psu.edu, Xiangyu Gao, Stefanus Jasin, Sajjad Najafi

We consider a pricing problem for a set of products displayed on a list. We assume a general cascade click model, in which customers examine the products in decreasing order of display, from the top to (potentially) the bottom of the list. At each step, customers can decide to either purchase the current product, forego the current product and continue examining the next product, or simply terminate the search without purchasing any product. We develop online algorithms that jointly learn the unknown parameters and optimize the prices of the products. We provide theoretical performance guarantees for the algorithms and test their empirical performance using numerical experiments.

3 - Pricing under Choice Model with Consideration Set

Ruxian Wang, Johns Hopkins University, Carey Business School, Washington DC, DC, 20036, United States, ruxian.wang@jhu.edu

In this paper, we study the pricing problems in discrete choice models with consideration set.

4 - Dynamic Pricing under Consumers Sequential Search

Sami Najafi-Asadolahi, Santa Clara University, Santa Clara, CA, United States, snajafi@scu.edu, Sajjad Najafi, Chi-Guhn Lee, Steven Nahmias

In this paper, we consider a seller offering several vertically differentiated perishable products over multiple periods. In each period consumers sequentially search for and buy the product maximizing their utilities. We show that a perishable product's price can increase over time, which goes against the common intuition from the classic revenue management literature.

■ WD55

CC- Skagit 4

Sequential Decision Making in Revenue Management

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Garud N. Iyengar, Columbia University, New York, NY, 10027, United States

Co-Chair: Min-hwan Oh, Columbia University, New York, NY, 10027, United States

1 - Managing Customer Search: Assortment Planning for a Subscription Box Service

Yuan Guo, Duke University, Durham, NC, United States, yuan.guo1@duke.edu, Fernando Bernstein

Subscription box services provide customers a personalized selection of products from multiple stores delivered to the customers' homes. Customers first decide whether to order from such service or to actively shop at stores by considering their search cost and the expected utility of the search outcome. They then choose the product (or the no-purchase option) that provides the highest realized utility in the searched set. We consider the search box companies' problem to optimally select a set of products for each customer. We apply a cross-nested logit framework to model the interaction between the assortment contained in a box and the stores included in the consideration set under active search.

2 - Diffusion Approximations for Sequential Experiment Design

Rene A. Caldentey, The University of Chicago, Booth School of Business, Chicago, IL, 60637, United States, rene.caldentey@chicagobooth.edu, Victor Araman

We propose diffusion approximations for a class of sequential experiment design problems in which experimentation opportunities coincide with the epochs of a Poisson process. We illustrate our methodology in the context of a new product selection problem in which experimentation is driven by the outcome of a customer voting process governed be an MNL choice model.

3 - Shrinking the Upper Confidence Bound: A Dynamic Product Selection Problem for Urban Warehouses

Li Wang, Massachusetts Institute of Technology, Cambridge, MA, United States, li_w@mit.edu, Rong Jin, David Simchi-Levi, Xinshang Wang, Sen Yang

The recent rising popularity of ultra-fast delivery services on retail platforms fuels the increasing use of urban warehouses, whose proximity to customers makes fast deliveries viable. The space limit in urban warehouses poses a problem for the online retailers: the number of products (SKUs) they carry is no longer “the more, the better”, yet it can still be significantly large, reaching hundreds or thousands in a product category. In this paper, we study algorithms for dynamically identifying a large number of products (i.e., SKUs) with top customer purchase probabilities on the fly, from an ocean of potential products to offer onretailers’ ultra-fast delivery platforms.

4 - Thompson Sampling for Multinomial Logit Contextual Bandits

Min-hwan Oh, Columbia University, New York, NY, 10027, United States, m.oh@columbia.edu, Garud N. Iyengar

We study a dynamic assortment selection problem where the goal is to offer a sequence of assortments that maximizes the expected cumulative revenue. The feedback here is the item that the customer picks from the assortment, which is given by a multinomial logit model. The utility of each item is a dynamic function of contextual information of both the item and the user. We propose Thompson sampling algorithms which simultaneously optimize assortment selections and learn customer’s preference, balancing between exploration and exploitation.

■ WD56

CC- Skagit 5

Operations Management/Marketing Interface IV

Contributed Session

Chair: Sreejith Kumar Krishnakumar, State University New York at Buffalo, Atlanta, GA, 30339, United States

1 - Physical Showrooms vs. Virtual Showrooms: Optimal Information Provision Strategies in Online and Offline Competition

Haozhen Deng, Xi’an Jiaotong University, Xi’an, China, dhz0202@126.com, Gengzhong Feng, Kwai Sang Chin

Due to frictions caused by product fit uncertainty, online retailers are at disadvantage when selling products with nondigital attributes. Online retailers can invest to disclose product fit information to strategic consumers through physical showrooms or virtual showrooms. We develop a game-theoretical model to investigate an online retailer’s optimal information provision strategies confronting the competition from a traditional retailer. It shows that physical and virtual showrooms have distinct effects on the two competing retailers’ interplay. We also derive some insights about physical showrooms location decisions.

2 - Retailer Financing vs. Crowdfunding: Impacts of Consumer Valuation Uncertainty and Influencer Marketing

Zhixin Chen, University of Technology and Science of China, Hefei, China, chenzhix@mail.ustc.edu.cn, Xiang Ji, Jie Wu

Since more and more online retailers opening their own crowdfunding platforms, here emerges one issue, which is whether a retailer should finance a capital-constraint supplier or induce it to do crowdfunding. We show that a retailer can have more incentives to finance with a more uncertain or less communication markets.

3 - Strategic Implications of Binge Consumption for Entertainment Goods: An Analysis of Network Television

Franco Berbeglia, Carnegie Mellon University, Pittsburgh, PA, United States, fberbegl@andrew.cmu.edu, Timothy Derdenger, Kannan Srinivasan, Joseph Xu

With the broadcast television industry facing new forms of competition, networks have searched for new methods to distribute shows. Through the networks’ online interfaces shows are able to match the new competitors and offer all-at-once releases rather than follow the traditional linear strategy. This lowers consumers’ viewing costs, but also diminishes the viewer’s responsiveness to advertising. This paper studies the impact of this new channel on network shows with a signaling model. We find the adoption of this channel is highly profitable for low quality shows, reducing the necessity of costly signaling through advertising for the high quality shows, which results in a more efficient market.

4 - Pricing and Advertising under Spillover Effect of Product Harm Crisis

Arka Mukherjee, Concordia University, Montreal, QC, Canada, ar_mukh@live.concordia.ca, Satyaveer Chauhan

Aftereffects of a product harm crisis of a firm often spill over to the firm’s competitors. Under a game theoretic framework, we study the variations in pricing and advertising decisions for a firm and its rival in the pre-crisis and the post-crisis regimes. Our findings highlight the importance of crisis likelihood and damage on which the firms’ decisions depend.

5 - The Value of Opaque Selling When Consumers Are Heterogeneous in Their Horizontal Preferences for a Given Product

Yi Liu, Penn State University, University Park, PA, United States, yml5188@psu.edu, Nicholas C. Petruzzi

We consider a firm that sells a product defined by both vertical and horizontal attributes to consumers characterized by heterogeneous preferences for the horizontal attribute. We explore the extent to which the firm should be transparent versus opaque in describing its product’s horizontal attribute. Accordingly, we establish the value of opaque selling by comparing the firm’s optimal expected profit against the benchmark expected profit associated with full transparency. We find that opaqueness should increase as the vertical attribute increases. Moreover, we find that opaque selling could yield a win-win in the sense that it could increase both the firm’s profits and consumer surplus.

6 - Individual and Organizational Determinants of Firm Omni-channel Capability Development

Sreejith Kumar Krishnakumar, State University New York at Buffalo, Buffalo, NY, United States, sk374@buffalo.edu, Suresh Nallan C, Rajiv Kishore

The retailing landscape has changed dramatically in the last decade and customers can interact with a firm through several channels. This has entailed many firms to pursue omni-channel (OC) capability development. This pursuit requires firms to undertake a series of tasks over time and chief executive officers (CEOs) differ in their attentional foci. In this study we examine key impacts of external and internal foci on OC capability development. We also examine the moderating roles of these foci with other important variables. Data for the study comes from firm annual reports, the Standard and Poor (SP) and Compustat databases for the years 2009 to 2017.

■ WD57

CC- Yakima 1

Joint Session PSOR/Practice Curated: Managing Welfare Delivery Supply Chains

Sponsored: Public Sector OR

Sponsored Session

Chair: Sripad K Devalkar, Indian School of Business, Hyderabad, 500032, India

1 - Using Mobile Pantries to Improve Food Bank Distribution Equity and Capacity

Manoj Vanajakumari, University of North Carolina Wilmington, 601 S. College Rd, 3367 Tamu, Wilmington, NC, 28403, United States, Jon M. Stauffer, Subodha Kumar

Food banks provide food assistance to millions of food insecure people every year in the United States and other countries around the world. We examine how regional food banks can use mobile pantries to supplement their distribution network for more equitable food distribution. In addition, mobile pantries can be used to facilitate faster distribution of perishable foods, such as produce and dairy products. We use parameters taken from real-world food bank operations to determine the additional mobile pantry cost required to achieve near-perfect equity and reduce perishable food spoilage.

2 - Supply Chain Interventions to Mitigate Health Commodity Stock-outs: An Empirical Study

Amir Karimi, University of Minnesota, Minneapolis, MN, 55408, United States, karim100@umn.edu, Karthik V. Natarajan, Kingshuk K. Sinha

Public health supply chains in developing countries commonly use two types of distribution channels in order to deliver health commodities from upstream warehouses to health facilities in the last-mile, namely pull and push distribution channels. We use data from the field to develop contingencies of pull-push strategies.

3 - Impact of Introducing Coarse Cereals in the Indian Public Distribution System

Sripad K. Devalkar, Indian School of Business, Hyderabad, 500032, India, sripad_devalkar@isb.edu, Sarang Deo, Bhavna Jha

Coarse grains such as sorghum and other millets are rich in micro-nutrients and resilient to climate change. Distributing coarse grains through the Public Distribution System (PDS), India's food security program, can incentivize their production and target the main consumers of these grains. We show that introducing coarse grains can lead to up to 17% reduction (~ INR 115 billion) in operational costs, with coarse grains comprising 15% of the total volume of food grains distributed. Beyond reduction in operational costs, including coarse grains in the PDS can also reduce reliance on a few states for food grain procurement and ensure a better match of PDS supply with household consumption patterns.

4 - Fair and Efficient? A Data-driven Approach to Capacity Allocation of Mobile Family Planning Services in Uganda

Philippe Blaettchen, INSEAD, Boulevard de Constance, Fontainebleau, 77305, France, philippe.blaettchen@insead.edu, Andres Alban, Harwin de Vries, Luk N. Van Wassenhove

Modern contraceptive methods are still out of reach for 225 million women, which has immense consequences for health and development. We study mobile service teams providing contraceptive services in rural communities of developing countries. Drawing on diffusion theory, we develop a model to optimize team allocations that captures both fairness and efficiency considerations. To this aim, we need to maximize a sum of sigmoidal functions, which has received little attention in literature so far. We further calibrate the model based on data from over 300,000 client interactions in Uganda, allowing us to make relevant contributions to practitioners in this highly important field.

■ WD58

CC- Yakima 2

Big Data VI

Contributed Session

Chair: Xueqi Zhao, Penn State University, State College, PA, 16801, United States

1 - The Effect of Future Launch on Spot Market: Evidence from Bitcoin

Zheshi Chen, Harbin Institute of Technology, Harbin, China, Bin Fang, Qiang Ye, Wenjun Sun

The launch of Bitcoin futures in 2017 provides us a unique opportunity to investigate the effect of the future market on spot market. Employed with the high-frequency data collected from Binance Exchange, we leverage the weighted moving average of Bitcoin return to measure volatility. Results suggest that the Bitcoin's volatility significantly increased after the introduction of the future. Moreover, Bitcoin futures account a very small fraction of determinant of volatility of both Bitcoin's volatility and price. By contrast, Google Trend search volume's explanation ability is 10 times larger than that of the futures. This study extends the informed traders' theory on the Fintech area.

2 - Clustering Transportation Companies' Trajectory Data

Mohammad Ali Alamdar Yazdi, Johns Hopkins University, Baltimore, MD, United States, yazdi@jhu.edu, Amirhossein Alamdar Yazdi

Transportation companies usually keep a database of trajectory data of their trucks, sampled very frequently every day. Such databases, in their raw formats, are very large and difficult to be used for optimization and statistical analysis. In this paper, we used some innovative big data mining methods to analyze and cluster the trajoctory data of an american transportation company with the size of 1.5 billion data points.

3 - Using Big Data on Fan Base Growing and Loyalty Building – A Case Study on San Jose Earthquakes

Hongwei Du, California State University-East Bay, Hayward, CA, United States, hongwei.du@csueastbay.edu

Big data in sports industry has been gaining momentum since at least 2008. Sports fans are becoming much more than just sports consumers. They no longer just watch—they participate, analyze, critique, fantasize and connect with their favorite players and teams in real time. Indeed, fans are increasingly becoming true brand partners. Utilizing Big Data can help advance the sports fans' experience as teams and ticket vendors compete with the at-home experience. The better they know their fans, the better they can cater to them. Big data and analytics capabilities can provide insights into fan preferences. This paper takes a look on how the San Jose Earthquakes have incorporated the analytics of Big Data.

4 - Predicting In-patient Discharges to Identify Bed Availability for Housekeeping During Emergency Department Surge Using Machine Learning Algorithms

Tahera Yesmin, PhD Student, University of Toronto, Ontario, ON, Canada, tahera.yesmin@mail.utoronto.ca, Michael W. Carter

Prolonged patient waiting time in the Emergency Department (ED) for an inpatient bed after the admission decision, is considered a global crisis and the most cited reason for ED crowding. When a hospital operates close to capacity and has hospital-wide inefficiencies in patient flows, ED boards the admitted patients until the inpatient bed is available.Housekeeping is crucial in patient-flow from ED to inpatient bed. A delay in bed cleaning causes a delay in patient flows and thus, contributes to ED crowding. Therefore, this research aims to apply machine learning algorithms to identify the number of beds available by predicting number of in-patient discharges during ED surge.

5 - Distributional Clustering: A Distribution-preserving Clustering Method

Arvind Krishna, Georgia Institute of Technology, Atlanta, GA, United States, akrishna39@gatech.edu, Simon Mak, Roshan Joseph

One of the key uses of clustering is to identify representative points from a dataset of interest via cluster centers. However, a drawback of k-means clustering is that it induces a distortion between the distribution of its cluster centers and that of the underlying data. To address this shortcoming, we propose a new clustering method called 'distributional clustering', where cluster centers capture the distribution of the underlying data. We first prove the asymptotic convergence of the proposed cluster centers to the data generating distribution, then propose an algorithm for computing them in practice. Finally, we demonstrate the effectiveness of our method on synthetic and real datasets.

6 - Intrinsic Geometrical Methods for Statistical Process Control of Complex Data Objects

Xueqi Zhao, Penn State University, State College, PA, United States, xuz206@psu.edu

Complex and not only big data are everywhere in industry and how to control and optimize systems based on these data types is an important aspect of modern Quality Engineering. We present a new approach for statistical process monitoring of point cloud, mesh and voxel data based on intrinsic geometrical features of the 2-D manifold (surfaces) of scanned manufactured parts. Monitoring intrinsic properties avoids computationally expensive registration pre-processing of the data sets. Our proposal brings SPC closer to computer vision and computer graphics methods.

■ WD59

CC- Chelan 2

Smart and Connected Manufacturing

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Hongyue Sun, University at Buffalo, Buffalo, NY, 14260, United States

Chair: Chen Kan, University of Texas-Arlington, University of Texas-Arlington, Euless, TX, 76039-6215, United States

1 - Robust Tensor PCA with a Novel Subspace Regularization Algorithm

Bo Shen, Virginia Tech, Blacksburg, VA, 24061, United States, Zhenyu Kong

In this work, a robust tensor PCA (RTPCA) formulation is proposed to obtain the subspace. The robustness is justified by providing the equivalence between Lp-norm based formulation and sample weighted L2-norm formulation. In addition, a subspace regularization algorithm is developed to obtain the solution for RTPCA and the convergence of this algorithm is investigated. The experiments demonstrate the robustness of our formulation and effectiveness of the proposed algorithm

2 - Sequential Design Using Stochastic Kriging

Yiming Che, Binghamton University, Binghamton, NY, United States, Changqing Cheng

Process design plays a paramount role in manufacturing quality assurance and enhancement. In this talk, we present the optimal sequential design considering both intrinsic and extrinsic uncertainty. While intrinsic uncertainty is quantified by generalized polynomial chaos, it is oftentimes tedious to evaluate this type of uncertainty for stochastic simulation. The sequential design based upon stochastic Kriging provides a guideline to distribute computational resource in the design space.

3 - Individualized Degradation Modeling and Prognostics in a Heterogeneous Group via Incorporating Static Covariate Information of Units

Minhee Kim, University of Wisconsin–Madison, 1513 University Avenue, Madison, WI, 53706, United States, mkim555@wisc.edu, Changyue Song, Kaibo Liu

In this study, we propose a generic framework which handles the heterogeneity across units by effectively leveraging the covariates of each unit, i.e., the distinct individual characteristics, which are closely related to each individual unit's degradation process. The significant advantage of this approach is to enable us to efficiently transfer the information among units according to the covariates' similarities. In this way, the collected degradation signals from one unit can be shared with the entire heterogeneous group, enhancing degradation modeling and prognostics of other units.

4 - Real-time Data-driven Quality Assessment for Continuous Manufacturing of Carbon Nanotube Buckypaper

Xinran Shi, Georgia Institute of Technology, Atlanta, GA, 30329, United States, xshi80@gatech.edu, Xiaowei Yue, Jianjun Shi, Zhiyong Liang

Carbon nanotube buckypaper (CNT BP) has great potential as a multifunctional platform material. However, the mass applications have run into significant bottlenecks with the large variability in quality during fabrication. Producing high-quality CNT BP at an industrial scale is urgent. Although Raman spectroscopy has been applied to study CNT BP's characteristics, a systematic method for CNT BP quality assessment is needed. We propose a real-time data-driven quality assessment method to quantify CNT BP's quality during fabrication. The proposed method reflects CNT BP quality regarding consistency and uniformity. A case study shows the method demarcates CNT BP quality in a unified manner.

■ WD59a

CC- Chelan 3

Data Mining VIII

Contributed Session

Chair: Navid Matin Moghaddam, Arizona State University, Tempe, AZ, 85281, United States

1 - Estimating Product-choice Probabilities from Sequences of Page Views

Naoki Nishimura, Recruit Lifestyle Co., Ltd., Tokyo, Japan, nishimura.n.ab@gmail.com, Noriyoshi Sukegawa, Yuichi Takano, Jiro Iwanaga

Understanding customers' product-choice behavior is an important issue for companies that operate e-commerce sites. This talk presents a method to estimate the customers' product-choice probabilities from sequences of their page views (PVs). Our method calculates the product-choice probabilities under shape restrictions reflecting properties of PV sequences. Computational results illustrate the efficacy of our method by comparison with standard methods for product-choice analysis.

2 - Reading Less in Haze the Impact of Air Pollution on Digital Reading Market

Yongjun Li, USTC, Hefei, China, lionli@ustc.edu.cn, Lizheng Wang

We adopt a regression discontinuity design approach to identify the impact of air quality on the digital content market and reveal the underlying mechanism. Identification results show that people reduce their reading time by 4.3 minutes each day when the air is polluted. In addition, people reduce their willingness to pay by 5.9% simultaneously. The results show that the impact of air pollution on us far exceeds our perception. For marketers, this study provides insights on how to conduct real-time air pollution based promotion strategies for a wider product range.

3 - Preferences Estimation under Bounded Rationality: Identification of Attribute Non-Attendance using SYM

Veronica Díaz Gómez, Universidad de Antofagasta, Antofagasta, Chile, veronica.diaz.gomez@uantof.cl
Veronica Díaz Gómez, Universidad de Chile, Santiago, Chile, veronica.diaz.gomez@uantof.cl, Ricardo Montoya

There is a growing interest in Economics regarding estimating preferences when consumers partially ignore the information provided in a choice experiment. This problem was introduced as attribute non-attendance by Scarpa et al. 2009. We propose a machine learning approach based on Support Vector Machines to identify non-attendance attributes at an individual level and to predict consumer choices in a conjoint experiment. We compare the performance of our proposed approach to different benchmarks from the literature. Our simulation study results show a higher performance in terms of the identification of non-attended attributes that improve the predictive ability of consumers' choices.

4 - Debunking False Health Information: A Text-Mining Approach

Jiexun Li, Western Washington University, Bellingham, WA, United States

In recent years, a lot of false health information has emerged and spread over the Internet. This study investigates this problem by analyzing data collected from two fact-checking websites, Snopes and PolitiFact. Topic analysis reveals frequent words and common topics occurring in these claims spread online. Furthermore, using text-mining and machine-learning techniques, this study builds prediction models for detecting false information and shows promising performance. Several textual and source features are identified as good indicators for true or false information in medical and health care.

5 - Teacher-school Assignment with Forward-looking Stability

Navid Matin Moghaddam, Arizona State University, Tempe, AZ, United States, nmatinm@asu.edu, Jorge Sefair, Margarita Pivovarova

Teacher retention has been identified as a pressing problem for Arizona's public schools. In this study, we analyze a longitudinal census of teacher data and develop supervised learning methods to identify rate of movements based on the characteristics of the teachers and schools in each assignment. Utilizing the results of the analysis, we model the movement as a stochastic process and develop a method that recommends stable assignments. Major outcome of the project is creating a tool for schools and school districts that would help them to make better hiring decisions resulting in long-term stable employment thus reducing both monetary costs and non-pecuniary costs.

■ WD60

CC- Chelan 4

Data-Driven Modeling and Monitoring in Smart Manufacturing System

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Yifu Li, Virginia Tech, Blacksburg, VA, 24061, United States

Co-Chair: Ran Jin, Virginia Tech, Blacksburg, VA, 24061, United States

1 - Family Learning: A Process Modeling Method for Cyber-additive Manufacturing Network

Lening Wang, Virginia Tech, Blacksburg, VA, 24061, United States, wangln@vt.edu, Xiaoyu Chen, Daniel Henkel, Jeffrey Burdick, Jingran Li, Ran Jin

A Cyber-manufacturing system (CMS) poses significant challenge in data-driven modeling for mass personalization, primarily due to limited sample sizes. As a results, most existing data-driven models may not provide satisfactory prediction accuracy, which motivated us to propose a new method called family learning. In this research, the similar-but-non-identical selective laser melting (SLM) processes are modeled as family members. Similarities among family members are quantified by designs and settings. The similarities are further used to penalize the differences among model coefficients of family members. A simulation and a real case study in SLM validate the proposed method.

2 - Filtering and Distributed Modeling in Smart Manufacturing Systems

Yifu Li, Virginia Tech, Blacksburg, VA, 24061, United States, Xinwei Deng, Hao Yan, Ran Jin

A smart manufacturing network collects high-volume data for process modeling and monitoring, and it is important to ensure data quality through filtering. Therefore, we propose an unsupervised data filtering algorithm and a filtering information criterion, which determines the appropriate proportion of data to preserve. Furthermore, to model multiple similar-but-non-identical manufacturing systems in a network, we proposed a multi-task learning framework by decomposing the variation among systems into explainable variation and latent variation. The simulation and case studies in crystal growth manufacturing demonstrate the superior computational performance of the proposed method.

3 - Adaptive Compressive Sensing for Anomaly Detection

Xinyu Zhao, Arizona State University, Tempe, AZ, United States, xzhao119@asu.edu, Hao Yan, Chen Zhang

Online anomaly detection is essential in various scenarios to ensure the system is in a healthy condition. Some practical information acquiring techniques are necessary when the sensing resources are limited. Compressive sensing is well known for its ability to reconstruct the signal with a limited amount of information. Here, we propose a Bayesian compressive sensing framework for online change detection, hypothesis testing, and active learning to select the sensing matrix adaptively. The proposed framework is validated through both simulation and case study.

4 - Causality Assessment in Industry 4.0 Applications

Ron S. Kenett, Senior Research Fellow, KPA, Raanana, Israel, ron@kpa-group.com

Judea Pearl, the 2011 Turing Award winner who developed Bayesian networks and causality networks, calls for a "causality revolution". Causality has been treated by statisticians since the work of R. A. Fisher at Rothamsted agricultural station on designed experiments. The gold standard for determining causality has been the randomized controlled trial (RCT). A general framework for handling causality, from observational data, is based on propensity score methods developed by Donald Rubin. The talk will review such tools and discuss applications to condition-based maintenance (CBM) and Industry 4.0.

5 - Distributed Family Learning in Cyber Manufacturing Modeling

Yutong Zhang, PhD. Student, Virginia Tech, Blacksburg, VA, 24060, United States, Lening Wang, Xiaoyu Chen, Ran Jin

Due to high volume data in cyber manufacturing systems (CMS), traditional centralized computing (e.g., Cloud computing (CC)) has problems in latency and reliability. Thus, advanced data-driven models cannot be efficiently utilized in centralized computing. This work proposed to adopt alternative direction method of multipliers to decompose penalized regression models (e.g., family learning) into a distributed manner in Fog-Cloud computing (FCC). The simulation result indicates that the method on FCC shows better redundancy and latency than CC with identical accuracy. The method can contribute to responsive decision-making for CMS compared with current centralized computing systems.

■ WD61

CC- Chelan 5

Predictive Maintenance

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Yan-Fu Li, Tsinghua University, Tsinghua University, Beijing, 100084, China

1 - Integration of Crack Detection and Probabilistic Fatigue Damage Prognosis

Yan-Fu Li, Tsinghua University, Haidian District, Beijing, 100084, China, Shan Jiang

The uncertainties of material properties and loading condition are discussed. A second-order polynomial regression model is developed for fatigue crack detection. The Paris law is employed to predict fatigue crack growth behavior. Moreover, the likelihood function is built, which incorporates the regression crack detection model and the Paris law. The posterior distribution of parameters can be estimated by Bayesian updating. The fatigue crack growth is recalculated by using the posterior distribution of parameters. The proposed approach can precisely predict fatigue crack growth.

2 - Degradation Based Optimization of Operating and Maintenance Schedule in Smart Grids

Chengwu Shao, Tsinghua University, Beijing, China, scw18@mails.tsinghua.edu.cn, Tarannom Parhizkar, Yan-Fu Li

Power flow optimization in smart grids depends on maintenance schedule of distributed generation (DG) systems. In order to achieve maximum profit, power flow and maintenance schedule of DGs should be optimized simultaneously. Another significant factor in optimization procedure is component degradation. Component degradation rate depends on DG type and its operating conditions, affecting fuel cost and maintenance schedule of the DG. In this paper, a framework for degradation based optimization of power flow and maintenance schedule in smart grids is developed.

3 - Predictive Maintenance for Infrastructure Assets under Environmental Risks

Zhenglin Liang, PhD, Tsinghua University, Beijing, China, zhenglin_liang@sina.com

We propose a novel approach to predict the remaining useful life for concrete infrastructure that exposes to the risk of the changing environment. The stochastic aging of concrete infrastructure is modelled by a continuous-time semi-Markov chain. To reduce the computational burden, we combine hypo-exponential approximation and phase-type prediction to forecast the remaining useful life with uncertain inspected information about the infrastructure condition and its surrounding environment. Then, we investigate the impact of different types of environmental risks. The overall approach is implemented on bridge predictive maintenance to gain resilience against environmental risks.

4 - Optimal Predictive Maintenance for a Deteriorating K-out-of-N: G Warm Standby System

Hui Wu, Tsinghua University, Beijing, 100084, China, wuh18@mails.tsinghua.edu.cn, Yan-Fu Li

This paper investigates a novel predictive maintenance policy with multi-level decision-making for an n-component deteriorating system with a k-out-of-n: G structure, where economic dependence, structural dependence and failure dependence are all considered. Decisions are made based on the remaining useful lifetime of the components and the system. Furthermore, a mathematical cost model of reliability-based opportunistic predictive maintenance strategies is developed to obtain the optimal maintenance decisions by minimizing the long-run average cost per time unit. Illustrative examples are provided.

■ WD62

CC- Tahoma 1

Appointment Scheduling in Healthcare Systems

Sponsored: Health Applications

Sponsored Session

Chair: Mohammad Dehghanimohammadabadi, Northeastern University, Boston, MA, 02115, United States

1 - A Multi-objective Outpatient Appointment Scheduling: A Data-Table Input Simulation-Optimization Approach

Mohammad Dehghanimohammadabadi, Northeastern University, Boston, MA, United States, Mandana Rezaeiahari, Javad Seif

Appointment scheduling is one of the key factors to enhance patient satisfaction in healthcare services. A robust appointment scheduling pattern allows clinics to utilize medical assets, equipment, and resources in an efficient manner. This study proposes a practical appointment scheduling of patients using an integrated simulation-optimization framework. In this multi-objective simulation-optimization problem, the concept of data-table input experiments (appointments table) is applied in a simulation environment, to determine the most preferred appointment scheduling pattern for an outpatient clinic system with stochastic parameters including patient-no-show and service time.

2 - A Stochastic Programming Approach for Chemotherapy Appointment Scheduling

Nur Banu Demir, Wayne State University, Detroit, MI, United States, demir.nb@gmail.com, Melih Celik, Serhat Gul

Chemotherapy appointment scheduling is a challenging problem due to uncertainty in pre-medication and infusion durations. We formulate a two-stage stochastic mixed integer programming model for the chemotherapy appointment scheduling problem under limited number and availability of nurses, and infusion chairs. The Progressive Hedging Algorithm is implemented and improved with a penalty update method, cycle detection and variable fixing mechanisms, and linearization of the objective function. We conduct experiments to compare our algorithm with several scheduling heuristics. Finally, we estimate the value of stochastic solution to assess the significance of considering uncertainty.

3 - Modeling Healthcare Operations: Utilizing a Simulation Model to Predict Future Capacity Needs at a High Volume Surgical Center

David P. Grace, Hospital for Special Surgery, New York, NY, United States, graced@hss.edu

The landscape of healthcare is rapidly changing. Across the industry, we are seeing reduced inpatient LOS and shifts from inpatient to outpatient care (e.g., knee and hip replacements) requiring new care models. Given that these types of changes can result in multiyear, multimillion dollar capital projects and major shifts in resource planning, estimating the impact of these changes over the next 5 - 10 years is critical. At our high volume surgical center we utilized discrete event simulation to assess how the changing environment may impact long-term capacity needs.

4 - Stochastic Policies for Scheduling Customer Preference-based Fields Visits

Yanlu Zhao, ESSEC Business School, Paris, France, Felix Papier

Motivated by the sales force operations of a B2B payment services company in Belgium, we develop a model for scheduling customer appointments for a team of sales agents. The appointments are made by a call center and subject to uncertain customer approval. We aim to maximize the number of sales appointments per agent. We formulate the model as a Markov decision process, demonstrate the existence of an optimal policy, develop an upper bound on optimal performance, and derive sensitivity properties on several parameters. Since the problem suffers from curse of dimensionality, we develop two scheduling policies that dynamically decide which clients to call and which time slots to propose to each client.

■ WD63

CC- Tahoma 2

Inverse Optimization in Healthcare Applications

Sponsored: Health Applications

Sponsored Session

Chair: Taewoo Lee, University of Houston, Houston, TX, 77204-4008, United States

1 - Inverse Optimization for Multi-objective Linear Programming

Masoud Zarepisheh, Memorial Sloan Kettering, New York, NY, 10017, United States, Mostafa Naghavi, Ali Asghar Foroughi

This work generalizes inverse optimization for multi-objective linear programming where we are looking for the least problem modifications to make a given feasible solution a weak efficient solution. This is a natural extension of inverse optimization for single-objective linear programming with regular "optimality" replaced by the "Pareto optimality". This extension, however, leads to a non-convex optimization problem. We prove some special characteristics of the problem, allowing us to solve the non-convex problem by solving a series of convex problems.

2 - Data-driven Objective Selection in Multi-objective Optimization

Temitayo Ajayi, Rice University, Houston, TX, 77004, United States, Taewoo Lee, Andrew J. Schaefer

A challenge in IMRT planning is selecting which clinical objectives to use in the optimization. We use inverse optimization with a cardinality constraint to infer important objectives from historical data. We use two methods to efficiently select a subset of objectives. The first method is a greedy algorithm, and we provide theory, a generalization of results by Nemhauser (1978), to support our results. The second method is a heuristic that selects objectives based on user-prescribed similarity metrics. We compare the proposed methods to the cardinality-constrained inverse problem and show our method efficiently finds a small set of objectives that generates clinically viable treatment plans.

3 - Multi-point Inverse Optimization for Constraint

Kimia Ghobadi, Johns Hopkins University, Baltimore, MD, United States, kimia@jhu.edu, Houra Mahmoudzadeh

Consider an LP for which we know a set of observed solutions (i.e., a set of feasible points; e.g., provided by an expert). We may not know the exact constraints that shape the feasible region of the problem. We would like to find the exact feasible region. To this end, we propose a multi-point data-driven inverse optimization framework for recovering the full set of constraints. We focus on LP models in which the objective function is known but a subset of the constraint matrix is unknown. Our inverse framework recovers the entire constraint matrix such that all the past observations are feasible, and the best-observed solution becomes optimal or near-optimal.

4 - Learning Hidden Action Principal-Agent Models

Sema Nur Kaynar Keles, University of California-Los Angeles, Los Angeles, CA, 90024, United States, Auyon Siddiq

We propose a method for estimating principal agent models from historical data on contracts and associated outcomes. We show that the estimator is statistically consistent and can be formulated as a mixed integer linear program. We then introduce a solution technique based on hypothesis testing and column generation, and show that it produces an asymptotically optimal solution.

5 - Quantile Inverse Optimization: Improving Stability in Inverse Linear Optimization

Taewoo Lee, University of Houston, Houston, TX, 77204-4008, United States, tlee20@central.uh.edu, Zahed Shahmoradi

Inverse linear programming can be very sensitive to inconsistency, noise, and measurement errors in input data. We develop a new inverse linear programming approach that determines a set of objective functions of a linear program by addressing quantile statistics of optimality error. We show that the proposed inverse model improves on the previous models in terms of stability against noise and inconsistency in data. We propose an efficient algorithm to approximate the model by exploiting its connection to maximum clique problems.

■ WD64

CC- Tahoma 3

Product and Process Innovation in Healthcare

Sponsored: Health Applications

Sponsored Session

Chair: Zhili Tian, Coastal Carolina University, Florida International University, Conway, SC, 33327-2444, United States

1 - Adaptive Learning of Drug Quality and Optimization of Patient Recruitment for Clinical Trial with Dropouts

Zhili Tian, coastal Carolina Univ, Mt. Pleasant, SC, 33327-2444, United States

Clinical trials represent the largest cost in drug development, and has long been recognized as an important problem in operations management. The research challenge requires modeling the physical process of enrolling patients and belief about the efficacy of a new drug and a placebo, and the accurate modeling of the decision process. We develop an optimal policy for determining when to cancel, continue, or stop and go to market, for new drugs. Our model considers uncertainty in the performance of a new drug and a placebo, and characterizes the enrollment process. Our model captures the benefits of making decisions early to extend the time to market a drug under patent.

2 - What Information Do Health Information Consumers Seek Online?

Lina Zhou, The University of North Carolina at Charlotte, Charlotte, NC, 28223, United States

Patients increasingly use online questioning and answering sites to meet their health information needs. Despite existing analyses of user-generated content on questioning and answering sites, there is a lack of understanding of health information seekers from the perspective of information sharing. Additionally, empirical comparisons of different platforms are scarce. This research investigates the information sharing behavior across two types of platforms.

3 - The Determinants of Process Innovation

Ivan Lugovoi, HEC Paris, 1 Square Theodore Judlin, Jouy-en-Josas, 75015, France, ivan.lugovoi@hec.edu

Utilizing a unique dataset of the process-patent expert evaluations merged with the sales of 50 generic pharmaceutical products, we explore in depth the link between technological diversification in related/unrelated products and process innovation including its dimensions: novelty and scope. We find that diversification in related products negatively affects process innovation, novelty, and scope. Likewise, diversification in unrelated products has a negative association with process innovation and scope but positive effect on novelty. Moreover, experience with a focal product positively influence process innovation and scope but has a negative association with novelty.

■ WD65

CC- Tahoma 4

Healthcare Analytics

Sponsored: Health Applications

Sponsored Session

Chair: Eric Park, University of Hong Kong, Hong Kong

1 - Decision Making under Compliance Uncertainty

Kyohong Shin, KAIST, Yuseong-gu, Daejeon, 34141, Korea, Republic of, Taesik Lee, Yoorim Song

In many decision making problems in healthcare, decision makers are different from those who perform them, and compliance with optimal solution is often a concern; optimal policy is not followed and it results in suboptimal outcomes. Based on a conjecture that compliance with optimal decisions is influenced by preferences (or biases) of the decision performer, we formulate a sequential decision making problem that accounts for decision performers' preferences. A policy solution from this formulation is sub-optimal to the original decision problem, but yields better outcome under less than full compliance environment. Characteristics of the policy solutions are illustrated with examples.

2 - Unintended Consequences of Hospital Regulation: The Case of the Hospital Readmissions Reduction Program

Christopher J. Chen, Indiana University, London Business School, Bloomington, IN, NW14SA, United States, cch3@iu.edu, Nicos Savva

We study the impact of the Hospital Readmissions Reduction Program on admissions decisions. Exploiting variation in hospitals' financial exposure to the program, we show that hospitals tried to reduce readmission rates by increasing the number of patients that were classified as admitted for "observation," which avoided potential penalties associated with a regular admissions.

3 - Integrating New Diagnostic Tests into Emergency Department Workflow

Pengyi Shi, Purdue University, West Lafayette, IN, 47907, United States, shi178@purdue.edu, Jonathan Helm, H. Sebastian Heese, Alice Mitchell

In medical research, new diagnostic tests are evaluated solely on their efficacy in detecting an illness. However, ignoring the workload impact of introducing new tests into existing workflow can create barriers to adoption. In collaboration with an ED physician, we develop an analytical framework for evaluating the workload impact of adopting new tests. We derive useful structural properties and develop an efficient decomposition algorithm for settings with multiple patient classes. As a showcase, we apply our framework to a new test, D-dimer, for diagnosing Pulmonary Embolism to understand what characteristics make adopting it feasible and how to best integrate it into the ED workflow.

4 - Does Limiting Time on Ambulance Diversion Reduce Diversions? A Data-driven Analysis on the Role of Paramedic Compliance and Network Effect

Eric Park, University of Hong Kong, Pokfulam Road, Hong Kong, ericpark@hku.hk, Sarang Deo, Itai Gurvich

We study the effect of a policy intervention intended to reduce ambulance diversions in LA County, CA. The intervention succeeded in its purpose of reducing the time EDs spent on diversion but did not reduce ambulances being diverted. A possible explanation for this outcome, identified by our empirical analysis, is a combination of the ambulance operator's imperfect compliance to the ED diversion signals and the decrease in frequency of ambulances facing EDs on diversion. We build a simulation model to investigate the efficiency of such policy intervention limiting ED time on diversion in ED networks with varying level of congestion and operator compliance to the ED diversion signals.

■ WD66

CC- Tahoma 5

Reliability III

Contributed Session

Chair: Changxi Wang, Rutgers University, Nichols Apartment, Piscataway Township, NJ, 08854, United States

1 - L1 Splines with Optimized Knot Locations for Data Approximation and Application in Change Point Detection

Ziteng Wang, Northern Illinois Universtiy, DeKalb, IL, United States, zwang3@niu.edu

Spline-based models can be a very useful tool in modeling time series data, sensor collected data, urban and natural terrain data and in recognizing patterns and objects of problem-specific interest. Recent development of L1 splines show robustness and computational efficiency over conventional ones. To further expand the modeling capability of L1 splines, this research optimizes the location of spline knots which allow the spline to more accurately capture the data shape. Application on change point detection is demonstrated.

2 - Design of Usage-based Preventive Maintenance under Two-dimensional Warranties

Shizhe Peng, Shanghai Jiao Tong University, Shanghai, China, pengshizhe@sjtu.edu.cn

This paper, from the manufacturer's perspective, considers the problem of designing a usage-based preventive maintenance service in the context of a two-dimensional warranty. We use dynamic programming to show that the optimal policy is characterized by a time threshold and a sequence of failure rate thresholds. Specifically, the manufacturer performs preventive maintenance up to the time threshold, to bring the failure rate of the product back to its lowest level once it exceeds the corresponding failure rate threshold. Interestingly, we find that the time threshold is a random variable which depends on the usage rate and that the failure rate thresholds are functions of the cumulative usage.

3 - QSR Research and Activities in HK

Yao Cheng, The University of Hong Kong, Hong Kong, Hong Kong, yao.cheng.ise@gmail.com

HongKong is the center of logistics and smart manufacturing of east Asia; to guarantee the operation efficiency of the logistics networks and manufacturing systems, extensive research has been done on quality, statistics and reliability (QSR) in universities and research institutions in HK. In this talk, we will introduce the development of research and knowledge exchange (KE) activities on QSR in different domains in HK.

4 - Economic Design of Repetitive Inspection Plans via the Expectation-maximization Algorithm

Young H. Chun, Louisiana State University, Baton Rouge, LA, United States

We first propose a new multiple inspection plan under which each item is tested repeatedly until we have a sufficient number of positive or negative test results. We then deal with the problem of estimating three model parameters: the type I and II errors of a testing device and the fraction defective of incoming items. Because of computational difficulties in maximizing the likelihood of the three parameters, we propose the use of the expectation-maximization (EM) algorithm as an easy alternative. In a numerical analysis, we demonstrate the outstanding performance of our new inspection plan over previous ones.

5 - Stochastic Modeling of Multiple Corrosion Pits Growth

Changxi Wang, Rutgers University, Piscataway Township, NJ, United States, rucxwang@gmail.com, Elsayed Elsayed

Corrosion growth modeling is important in structure maintenance planning. Existing methods mainly model maximum corrosion pit depth growth. However, other features of corrosion growth such as corrosion volume growth may also lead to failures but have not been investigated. We develop a stochastic model that characterizes both corrosion volume and depth growth. The multiple corrosion pits growth and propagation are captured by a physics-based model and a degradation branching model. Field corrosion data are used for models validation. These models result in accurate prediction of the remaining lives and provide more characteristics such as the distribution of the failure time and its variance.

■ WD67

S- Virginia

Optimization, Combinatorial II

Contributed Session

Chair: Hadi Farhangi, Savannah State University, Savannah, GA, 31404, United States

1 - Design of Diversified Package Tours for the Digital Travel Industry: A Branch-cut-and-price Approach

Yanlu Zhao, ESSEC Business School, Paris, France, Laurent Alfandari

We consider the design of a fixed number of package tours offered to customers in digital travel industry. This can be formulated as a Team Orienteering Problem (TOP) with restrictions on budget and time. Our work introduces controlled diversity between tours. This enables the OTA to offer tourists a diversified portfolio of tour packages, each customer choosing a single tour in the selected set, rather than multiple independent tours as in the TOP. Tuning the similarity parameter between tours enables to trade off between individual preference and economies of scale. We propose compact and extended formulations and solve the master problem by a branch-and-price, and an branch-cut-and-price method.

2 - Solving A Real-world Multi-period Petrol Replenishment Problem with Complex Loading Constraints: A Branch-and-price Heuristic

Abderrahman Bani, PhD Student, Polytechnique de Montreal & GERAD, Montreal, QC, Canada, abderrahman.bani@polymtl.ca, Issmail El Hallaoui

In this paper, we solve a rich real-word Multi-Period Petrol Replenishment Problem (MPPRP) with a Branch-and-Price heuristic. The underlying network consists of five distinct depots, a group of five private carriers with heterogeneous fleets of tank-trucks and five types of gas to replenish three main groups of clients on a weekly basis. Due to the hazardous nature of the products carried, some complex handling rules apply and are addressed in the column generation sub-problem as an Elementary Shortest Path Problem with Resource Constraints. Acceleration strategies are discussed. Numerical results on some real-world data show the effectiveness and high potential of the proposed approach.

3 - Syntactical Circuits for Combinatorial Optimization Using Extensions of Dynamic Programming

Michal Mankowski, King Abdullah University of Science and Technology, Jeddah, Saudi Arabia

We developed an algorithmic framework for combinatorial optimization using Extensions of Dynamic Programming based on the circuit model which provides algorithms for series of single-criteria optimizations and bi-criteria optimization (construction Pareto front). A syntactical circuit is a new tool to work with problems where the optimal solution for subproblem might be an optimal solution for the initial problem. We will introduce an application of this tool to multi-objective 0/1 Knapsack problem.

4 - Comparison of the Number of Nodes Explored by CBFS-depth and BFS

Wenda Zhang, University of Illinois at Urbana-Champaign, Urbana, IL, United States, wzhang95@illinois.edu, Jason Sauppe, Sheldon H. Jacobson

When using Branch-and-bound (B&B) algorithms, a new search strategy called Cyclic Best First Search with depth contour (CBFS-depth) has been shown to consistently process fewer nodes than Best First Search (BFS) on several combinatorial optimization problems. In this paper, we study the conditions of the search tree that may lead to CBFS-depth outperforming BFS in terms of average number of nodes expanded to prove optimality. We propose a search tree model for B&B algorithms based on the distributions of nodes with different lower bounds and use it to compare the performance of both search strategies. Several problems are used to verify the conclusion from the generated search trees.

5 - Multi-period Set Covering Problem: Formulations, Applications, and Solution Methods

Hadi Farhangi, Savannah State University, Savannah, GA, United States

Set covering problem and its extensions to multiple periods of planning are studied in this work. Particularly, we studied different formulations of multi-period set covering problems and exact column generation approach for solving this class of problems.

■ WD68

S- University

Manufacturing and Neural Networks

Contributed Session

Chair: Alireza Aghasi, Georgia State University, Atlanta, GA, 30303, United States

1 - Development of Graphical User Interface GUI for Dimensional Accuracy Prediction on 3D Printing Process

Honglun Xu, The University of Texas at El Paso, El Paso, TX, United States, hxu3@miners.utep.edu, Carlos Garcia Rosales, Tzu-Liang (Bill) Tseng

A dimensional accuracy prediction using a Graphical User Interface (GUI) is presented. An artificial neural network (ANN) is developed for modelling dimensional error on 3D printed specimens. ANN training and testing phases using stereolithography (SL) historical data and results are compared for several variants of the ANN architecture. ANN results obtained will be compared using maximum Pearson correlation during testing.

2 - Automatic Alignment and Quickest Change Detection in Additive Manufacturing under a Multi-resolution Framework

Yu Jin, University of Arkansas-Industrial Engineering, Fayetteville, AR, United States, Haitao Liao

The in-situ layer-wise inspection of geometric accuracy is essential for wide application of Additive Manufacturing (AM). The shape of a layer can be described by a two-dimensional point cloud, which must be aligned with the corresponding base-truth model before evaluating its geometric accuracy. In this work, a multi-resolution framework is proposed for alignment and error quantification. Moreover, a quickest change detection algorithm is applied to identify the layer where the earliest systematic deviation distribution change occurs during the printing. A sample part with different featured layers is provided to illustrate the effectiveness and efficiency of the proposed methods.

3 - The Role of Stochastic Gradient Descent Algorithms in Generalization of Deep Learning

Navid Azizan, California Institute of Technology, Pasadena, CA, United States, Babak Hassibi

Stochastic descent methods have a long history in optimization, and have gained tremendous popularity as the workhorse of deep learning. It is widely believed that the success of deep networks is not just due to their special deep architecture, but also due to the behavior of the stochastic descent methods used. In an attempt to shed some light on why this is the case, we study some minimax properties of stochastic gradient descent and general stochastic mirror descent algorithms, from an $H\infty$ estimation theory perspective. This theory can be used to explain the convergence and “implicit-regularization” properties of such algorithms when the problem is highly over-parametrized, as in deep learning.

4 - On the Use of Multi-objective Optimization in Deep Learning Models

Alireza Aghasi, Georgia State University, Atlanta, GA, United States

There has been an increasing attention towards using deep learning models to simulate physical phenomena or address inverse problems. In many problems (e.g., the training of generative adversarial networks) model training is hard and often requires a careful selection of the minimization parameters. In this talk we discuss some multi-objective minimization schemes which could be used across different areas of deep learning. The proposed algorithms are more robust, showing favorable convergence properties, and require minimum parameter fine-tuning.

■ WD69

S- Seneca

Joint Session Telecom/TSL Urban: Multi-level Optimization in Network Applications

Sponsored: Telecommunications and Network Analytics

Sponsored Session

Chair: Changhyun Kwon, University of South Florida, Tampa, FL, 33620, United States

1 - Pessimistic Evasive Flow Capturing Problems

Changhyun Kwon, IMSE department, University of South Florida, Tampa, FL, United States, Aigerim Bogyrbayeva

The evasive flow capturing problem is to locate a set of law enforcement facilities to intercept unlawful flows and is typically formulated as a bilevel optimization problem. While optimistic bilevel formulations are studied in the literature, we consider pessimistic formulations by relaxing the assumption on the optimizing behavior of unlawful travelers. Such pessimistic formulations introduce another level in the optimization problem. We introduce a cutting plane algorithm for the pessimistic formulations.

2 - A New Bilevel Approach for the K-vertex Cut Problem

Ivana Ljubic, ESSEC Business School of Paris, Paris, 95021, France, Fabio Furini, Enrico Malaguti, Paolo Paronuzzi

The k-vertex cut problem is to find a subset of vertices of minimum weight, deletion of which separates the graph into at least k connected components. The problem is highly relevant for applications in networks analytics.

We provide a new ILP formulation, derived from the perspective of a two-phase Stackelberg game in which a leader deletes the vertices in the first phase, and in the second phase a follower builds connected components in the remaining graph. Our computational study demonstrates that this new ILP model (extended with variables and inequalities to model representatives of each component) significantly outperforms the state-of-the-art exact methods from the literature.

3 - Multilevel Approaches for the Critical Node Problem

Margarida Carvalho, University of Montreal, Montreal, QC, Canada, carvalho@iro.umontreal.ca, Andrea Baggio, Andrea Lodi, Andrea Tramontani

Network safety is modeled through a defender-attacker-defender game. It encompasses three phases: prevention, attack and recovery. This game is formulated as a trilevel mixed-integer program for which an exact algorithm is proposed. The computational results highlight the advantage of simultaneously integrating these three game stages on the determination of the defender’s optimal strategy.

4 - Modeling Defender-attacker Problems as Robust Linear Programs with Mixed-integer Uncertainty Sets

Juan S. Borrero, Oklahoma State University, Stillwater, OK, United States, juan.s.borrero@okstate.edu, Leonardo Lozano

We study a class of uncertain defender-attacker optimization problems where the defender has uncertainty about the data but can represent her limited knowledge by a mixed-integer uncertainty set. Given that the defender hedges against the worst possible data realization, the robust optimization problem becomes a bilevel bilinear problem with a mixed-integer lower level. We discuss two applications and reformulate the problem using semi-infinite and convex optimization. These reformulations are the basis for a cut generation and a Frank-Wolfe based algorithms. We provide theoretical convergence bounds for each algorithm and discuss their performance on numerical experiments.

■ WD70

S- Jefferson A

Accounting & Vehicle Routing

Contributed Session

Chair: Yongsen Zang, Tsinghua University, Tsinghua Yuan,Haidian, Beijing, 100084, China

1 - Sustainability of Social Enterprises and Acquiring Resources by Sending Market Signals

Junseok Goh, Seoul National University, Seoul, Korea, Republic of, junsgoh@gmail.com, Dan Hong

Social Enterprises solve societal issues by both pursuing economic and social returns and operating their business to create values for the society and for stakeholders. The survival of social enterprise is contingent upon their ability acquire capital and resources to sustain. The information asymmetry problem arises when principals who make investments to social enterprises (agents) do not observe social value being created. Drawing from signaling theory, this paper proposes that a third party, institutions who evaluate overall performances of social enterprises, can be a promising signal to investors. Firms engaged in a third party support shows easier access to debt financing.

2 - Flexibility Structure Evaluation and Routing Policy with Human Resource Considerations

Fengming Cui, Tsinghua University, Beijing, China, cfm16@mails.tsinghua.edu.cn

Most of organizations consist of staffs who can deal with multiple types of tasks. The multiskill agents provide structural flexibility to the organizations. This study examines several structure flexibility indices and routing policies from an organizational behavior perspective by incorporating human resource factors like emotional exhaustion. The objective of the study is to help design an effective flexibility structure and routing policy in organization operations management.

3 - Variable Tact Times for Mixed-model Assembly with Random Customization

Tobias Moench, WHU - Otto Beisheim School of Management, Vallendar, Germany, Arnd Huchzermeier

In case of a fixed tact system, raising the number of products to be assembled on a single line results in increased idle time as well as utility work and often requires an expansion of the line. To the contrary, a variable tact time approach is able to eliminate such line inefficiencies altogether, and diminishes the computational effort associated with line balancing and sequencing. We present a benchmark study of a global manufacturer of agricultural machinery where models differ greatly in assembly times and each product is uniquely customized.

4 - The Electric Vehicle Routing Problem Considering Different Battery Depreciation Strategies

Yongsen Zang, Tsinghua University, Beijing, China, zysthu@163.com

A growing body of work has shown that Electric Vehicle Routing Problem (EVRP) engenders greater benefits than VRP in the long run. Battery depreciation cost is one of the important key factors making against the benefits. We adopt three battery depreciation methods to pursue the influence for EVRP model: 1) charge-discharge cycles depreciation; 2) total driving distance depreciation; 3) battery depreciation with nonlinear function. To deal with the complexity of the models, a Column Generation algorithm relies on different labeling algorithms is designed. After computational studies and comparison of three models, several managerial insights are deduced for the better operation of EVRP fleet.

■ WD71

S- Jefferson B

Operations/Sustainability II

Contributed Session

Chair: Ozden Tozanli, University of Bridgeport, Bridgeport, CT, 06604, United States

1 - Product Recall Delay and Product Cycle

Hsiao-Hui Lee, National Chengchi University, Taipei, Taiwan, hsiaohui@nccu.edu.tw, Wenzheng Mao, Zhanyu Dong

When a safety defect occurs, manufacturers often use product recalls to mitigate potential consequences. Our empirical observation on large recalls in the automobile industry suggests that the timing of a recall is a key decision in this recall process, as we find that only recalls made in an early stage of a product cycle significantly influence future product sales. Our model confirms that when a product defect is discovered at an early stage of the product cycle, a firm may strategically delay the timing of a recall to mitigate the negative shock evoked by this recall. To avoid long-delayed recalls, governments need to note this behavior and design penalty/incentives accordingly.

2 - Product Remanufacturing in the Presence of Secondary Market Implications of Recollection Policy

Chang Dong, Hong Kong University of Science and Technology, Hong Kong, Hong Kong, cdongad@ust.hk, Qian Liu

We analyze the impact of strategic customers' p2p used goods transaction in a two-period model where a profit-maximizing firm successively sells two generations of a product in a market. A key message of our study is that due to strategic customers' inter-temporal purchase decision, the existence of p2p used goods market could either improve or reduce the benefit of the trade-in remanufacturing policy: the p2p used goods market acts as a double-edged sword. Moreover, in the stochastic depreciation case where there is uncertainty concerning the quality level of a used product, a trade-in program amounts to an intervention by the firm in the used goods "lemon" market.

3 - Preventing Free Riders in Collaborative Logistics: How to Share Joint Profits with Partners

Minyoung Yea, Korea University, Seoul, Korea, Republic of, ymy99@korea.ac.kr, Daeki Kim, Taesu Cheong

This study investigates a mechanism for sharing profits of horizontal cooperation in transportation. Collaborative logistics, which generates benefit by resources utilization, increases social welfare unless it approves inefficient acts. The proposed allocation rule is designed to mitigate "the tragedy of the commons" in shared logistics.

4 - Offering Trade-ins for Competitor's Used Products

Narendra Singh, Indian School of Business, Mohali, India, narendra_singh@isb.edu

Firms increasingly offer trade-ins for their competitors' used products. While such trade-ins may allow a firm to compete more aggressively, they may also increase resale value of competitors' products. I study the implications of a firm offering trade-ins to consumers who own used products sold by a competing firm.

5 - Evaluation of Trade-in-to-upgrade Policies as a Marketing Strategy for Smart Product Recovery

Ozden Tozanli, University of Bridgeport, Bridgeport, CT, United States, Elif Kongar, Surendra M. Gupta

Trade-in programs offer remarkable opportunities to manufacturers from environmental and economic standpoints. These programs while may be a significant asset to organizations, if not tailored properly, become a financial burden for producers who rely on qualified disassembly yields that would compensate for product acquisitions cost. Addressing this issue, this study presents the use of intelligent products in a blockchain-enabled disassembly-to-order (DTO) system to determine the optimal trade-in offer. A discrete-event simulation model is developed to obtain the expected cost of the DTO system. An optimal offer for varying product qualities is computed by utilizing the proposed model.

■ WD72

S- Columbia

Sharing Economy and Online Communities

Sponsored: Information Systems

Sponsored Session

Chair: Stephanie Lee

1 - An Empirical Analysis of the Role of Banner Ads in Mobile Games

Jiaying Deng, University of Washington, Seattle, WA, 98105, United States, jydeng2@uw.edu, Stephanie Lee, Yong Tan

Freemium games dominate the mobile game market and revenues from mobile games account for almost 90% of total app revenue on Google Play. However, in-game purchases rate is formidably low and most game publishers still rely on advertisement. On the other hand, there is a trade-off between advertisement revenue and gamers' nuisance cost. This paper investigates how the introduction of banner ads affects players' activities. The result shows that there is no significant change in players' daily playing frequency or session duration after the launch of banner ads. Second, gamers' intention to make no-ads purchase is significantly increasing.

2 - A Smart Solution to Rush-hour Traffic Congestion: Effects Dockless Bike-sharing Entry on Ride-sharing

Juan Qin, Harbin Institute of Technology, WA 98105, Seattle, WA, 98105, United States, jqin@uw.edu

We examine whether dockless bike-sharing can offer a technology-enabled smart solution to the traffic congestion problem by offering an environmentally-friendly, cost-effective, and sustainable mode of transportation. We exploit the natural experiment setting to examine the effect of dockless bike-sharing entry on the demand for ride-sharing car-travels during rush-hours. Using a difference-in-difference framework, we find that the entry of dockless bike-sharing reduces rush-hour ride-sharing orders, especially at congested regions.

3 - Can Match-funding Really Double Your Impact? Crowding Out in Donation-based Crowdfunding

Zhen Fang, University of Washington, Seattle, WA, United States, zhenfang@uw.edu, Shengsheng Xiao, Yong Tan

Match-funding has become a new measure of philanthropic marketing for large companies to match donation from individual donors dollar-for-dollar. Leveraging an open dataset from a large classroom crowdfunding platform, we conduct a natural experiment to examine the impact of match-funding and moderating effects of campaign progress. Our results show that match offers will significantly crowd out part of donations but accelerate the financing process by lowering actual objective amount and mitigating negative effect of donated percentage. Our findings have important implications for crowdfunding platforms and project owners on how to succeed in the presence of match-funding.

4 - Helpfulness of Video Reviews: A Study of Product Reviews on Youtube.com

Kyungmin Park, University of Washington, Seattle, WA, 98105, United States, Stephanie Lee, Yong Tan

This research explores the determinants of the helpfulness of online video review. By analyzing 10219 reviews from YouTube.com, we found the heterogeneous effect of review contents on the helpfulness of review by reviewer popularity. For popular reviewers, review subjectivity has a positive effect on review helpfulness. However, the effect is opposite for less popular reviewers. For both reviewer types, the level of information concentration has a positive effect on review helpfulness, but the reviewer type moderates the effect of the level of information concentration on review helpfulness.

■ WD73

S- Boren

Talking to the Top: Communication Upwards

Sponsored: INFORMS Section on Practice

Sponsored Session

Chair: Carrie Beam, University of Arkansas, Walnut Creek, CA, 94596, United States

Talking to the Top

Edward Cook, President, The Change Decision, Richmond, VA, 23230, United States, ed.cook@thechangedecision.com

Top decision-makers often consume information in a different manner than the analysts in the trenches produce it. And yet, in school or entry-level jobs, almost nobody explicitly teaches how to present upwards. This panel discussion will showcase best practices in communicating complex analytical results to top decision-makers. Our panelists have extensive experience making brief yet powerful executive presentations. Come join us, and learn how to present analytical information in a way your supervisors want.

PanelistS

- Edmund B. Levy, Walden University, Carson City, NV, 89702, United States, levyed512@live.com
- Edward Cook, President, The Change Decision, Richmond, VA, 23230, United States, ed.cook@thechangedecision.com
- Rajeev Namboothiri, GE Global Research, John F. Welch Technology Centre, Plot # 122, EPIP Phase 2,, Bangalore, 560066, India, rajeev.namboothiri@ge.com

Speaking Truth to Power - and Getting Buy-in

Patrick E. Leach, Adjunct Professor / Independent Consultant, Colorado School of Mines, Denver, CO, 80202, United States, leach.sullivan@gmail.com

■ WD74

S- Capitol Hill

Game Theory II

Contributed Session

Chair: Sam Ganzfried, Ganzfried Research, Miami Beach, FL, 33139, United States

1 - Online Channel Choices of a Farmer with Pick-your-own Operations

Bing Xu, Prof., Nanchang University, Nanchang, China, xu_bing99@sina.com

Nowadays, farmers are increasingly adopting pick-your-own (PYO) operational method in which consumers can pick agriculture products by themselves on the farm. In the context of e-commerce, farmers need to consider whether or not to operate online sales channels. To address this challenge, we investigate online channel choices of a farmer. Particularly, we consider three scenarios: No online channel; operating online channel itself; operating online channel via an e-tailers. The results show that the product freshness and online operation cost affect the farmer' choices among three scenarios.

2 - An Evolutionary Game Theory Approach to the Role of Government in Technology Transitions

Camila Apablaza, PhD Student, Georgia Institute of Technology, Atlanta, GA, United States, capablaza@gatech.edu, Valerie Thomas

The widespread adoption of alternative fuels and alternative fuel vehicles (AFVs) could have an important role in the task of curbing future emissions. The mass adoption of AFVs depends on a network of interactions between regulators, vehicles manufacturers, fuel providers, and consumers. This study uses an evolutionary game theory approach to model the network of stakeholders involved in the process of adopting AFVs in the transportation sector. This approach allows studying the changes in strategy chosen by each one of the game's players when a change in the environment happens. We examine the effect of regulation targeting AFVs in the strategy adopted by the stakeholders.

3 - An Algebraic Method About Power Asymmetry in the Graph Model for Conflict Resolution

Haiyan Xu, Nanjing University of Aeronautics and Astronautics, Nanjing, China, xuhaiyan@nuaa.edu.cn, Dequn Zhou, Zhihong Tu

An algebraic approach is proposed to implement the conflict analysis with asymmetric power based on the graph model for conflict resolution. The follower decision maker would like to take consensus preference with the leader decision maker and the leader may choose positive, negative or indifferent attitude towards the follower. The stability definitions for decision makers with asymmetric power are presented and the algebraic presentation is provided to implement algorithms efficiently. The energy pipeline conflict in the Central Asian Caspian is utilized to show how the proposed method work.

4 - Quality Improvement and Product Recall

Tulika Chakraborty, John Molson School of Business, Concordia University, Montreal, QC, Canada, jum.tulika@gmail.com, Satyaveer S. Chauhan

We consider a dynamic model of one-manufacturer purchasing a specific part from one-supplier to produce a finished product. Both members invest in product quality. The supplier is prone to product recall during the planning horizon. Our goal is to investigate the impact of the recall on pricing and quality decisions.

5 - Bounded Rationality with Information Cascading in Social Media

Guanxiang Yun, University of Central Florida, Orlando, FL, United States, Qipeng Phil Zheng

Social media have been popular platforms for people to share information. Expanding the connections can help commercial users make more influences. In order to optimize their network connections, we have a three-level math model to simulate behaviors of other users within the target user's network. We apply the linear threshold propagation model to determine the action of re-post. In addition, the action of following or un-following is restricted by boundedly rational user equilibrium (BRUE). We tackle this problem by using the heuristic large neighborhood search algorithms. We discuss the reasons why the BRUE model may be a more accurate simulation of users' actions compared to game theory.

6 - Optimization-Based Algorithm for Evolutionarily Stable Strategies Against Pure Mutations

Sam Ganzfried, PhD, Ganzfried Research, Miami Beach, FL, United States

Evolutionarily stable strategy (ESS) is an important solution concept in game theory which has been applied frequently to biology and even cancer. Finding such a strategy has been shown to be difficult from a theoretical complexity perspective. Informally an ESS is a strategy that if followed by the population cannot be taken over by a mutation strategy. We present an algorithm for the case where mutations are restricted to pure strategies. Our algorithm is based on a mixed-integer non-convex feasibility program formulation, which constitutes the first general optimization formulation for this problem.

■ WD75

S- Metropolitan Ballroom A

Flash Session IX

Flash Session

1 - The Effect of Distribution Center Processes on Supply Chain Inventory

James Bradley, Hays T. Watkins Professor, College of William and Mary, Williamsburg, VA, United States, james.bradley@mason.wm.edu

We show that the picking sequence in a distribution center, which serves downstream retail stores, affects the inventory in the supply chain when a common "ship-when-full" trailer dispatching policy is used. Further, we develop an effective heuristic picking sequence policy for minimizing inventory.

2 - The Influence of Franchisee Loss on Logistics Network: A New Perspective from NK Model

Yihang Feng, Huazhong University of Science and Technology, Wuhan, China, Bin Hu, Changying Ke

The development of Internet of Thing and new information technology makes the repaid expansion of their logistics network become possible. As the management of franchisee cannot keep pace with the speed of logistics network expansion, this mode has led to many management problems such as franchisee loss. We introduce NK model to launch our analysis from the perspective of vulnerability. In addition, efficacy and efficiency are proposed to measure the performance of logistics network. Results show that relatively small networks should focus on the enhancement of efficacy, while relatively large networks should make efforts in efficiency. Corresponding cases are introduced to confirm our results.

3 - The Selection of the Optimum Location for Wind Farms by MAUT and AHP: A Case Study

Behnaz Malaei, Graduate Assisstant, Binghamton University, Binghamton, NY, United States, bmalaei1@binghamton.edu

These days, the greater part of the world, unfortunately, depends intensely on non-renewable fossil fuels; meanwhile, wind energy continually self-renews. Diverse social and local criteria are as vital as the wind for the optimal location of wind power generation-transmission plants. Building wind farms requires a high investment. Therefore, location selection for wind farms has special importance. Since different methods present different results, decision-makers significantly apply more than one technique. This paper applies Multi-Attribute Utility Theory and Analytical Hierarchy Process methods with six different decision criteria to identify the optimum location for wind plants.

4 - Welfare Impacts of Optimal Virtual Bidding in a Multi-settlement Electricity Market with Transmission Line Congestion

Hyungkwan Kim, Lawrence Berkeley National Laboratory, Berkeley, CA, United States, hyungkwankim@lbl.gov, Paul V. Preckel, Douglas Gotham, Andrew Lu Liu

The objective of this research is to understand the effect of virtual transactions on electricity market efficiency using a model that explicitly includes the network as well as relationships that reflect the physical properties of electricity flows through a network (i.e. loop flow). The core research question is; what impact does network congestion have on the welfare shifts caused by the participation of financial virtual traders? Results indicate that optimal virtual bidding tends to decrease consumer welfare when the expected spot price is equal to the cleared forward price, and congested lines in the network can magnify the welfare changes while virtual traders essentially always benefit.

5 - When Do Acquirers' Absorptive Capacity Have Better Performance?

Yunjae Bae, Seoul National University, Seoul, Korea, Republic of, jaybae4606@gmail.com, Taewoo Roh

This study cumulates the importance of absorptive capability and future performance after obtaining extrinsic resources by acquiring other firms. Using United States International M&A transaction toward foreign companies during 2000-2014, we propose that the higher level of absorption capacity, the more likely to have better firm performance. In addition, this study used four moderate variables that would further effect on firm's future performance. From acquiring the firm's M&A information, we find that the firm's payment method of cash and past M&A experience positively creates a higher firm performance.

6 - A Matheuristic for Large-scale Capacitated Clustering

Mario Gnägi, University of Bern, Bern, Switzerland

Capacitated clustering problems consist of assigning a set of weighted objects to clusters such that the total weight of the objects in each cluster does not exceed a cluster-specific capacity. The objective is to minimize the total distance between the objects and their respective cluster centers. Typical applications include facility location and customer segmentation. State-of-the-art approaches for capacitated clustering problems scale up to instances with 10,000 objects. Here, we present a new type of matheuristic for instances with up to 100,000 objects.

7 - The Value of Blockchain in Smart City Energy Management

Pranathy Enamela, University of North Texas, Denton, TX, United States, pranathyenamela@my.unt.edu, Abdulrahman Habib, Victor R. Prybutok

This study explores the use of blockchain by smart cities to increase the likelihood of sustaining an uninterrupted supply of electricity. Review of theory allowed development of a conceptual model that supports the value of data processing in smart grids. The posited model supports the need for better integration between platforms and providers to enhance city wide distribution of energy.

■ WD76

S- Metropolitan Ballroom B

Bayesian Approach & Retail Management

Contributed Session

Chair: Kyle Maclean, Ivey Business School

1 - Bayesian Business Analytics

Adam Jason Fleischhacker, University of Delaware, Newark, DE, United States

We introduce an R package, causact, that provides an intuitive, yet powerful, interface into probabilistic programming. Causact's goal is to accelerate the complete Bayesian business analytics workflow - including strategy elicitation with c-level execs, creating/visualizing probabilistic graphical models, computing posterior distributions with Hamiltonian Markov Chain Monte Carlo, and data visualization to persuade stakeholders to take action.

2 - Consumer Response Behavior: A Cross-Category Targeting Perspective

Sri Devi Duvvuri, Assistant Professor, University of Washington Bothell, Bothell, WA, United States, duvvuris@uw.edu

Very often retailers are in situations where they have to target customers who have not made a purchase in the categories under consideration. Are there methodologies that can help generate response sensitivities for customers with no purchase histories? In this research, we propose a multivariate probit framework that derives consumer response sensitivities for such customers. We use scanner panel data across multiple categories to calibrate the model. We validate model results and derive marketing metrics using survey data from the same panel of customers. We use Hierarchical Bayesian methods (MCMC) to infer model parameters.

3 - An Optimal Assortment for Complements and Category Coordination

Xi Shan, Boston College, Boston, MA, United States, Chenglin Zhang, Dorothee Honhon

Using complements is common practice in assortment planning: Restaurants offer meals with drinks or a music environment and even allow consumers to bring their own wine. Department stores use one category as a complement to the other categories to stimulate purchases.

4 - Assortment Planning with Satisficing Consumers

Forough Pourhossein, Sauder School of Business, University of British Columbia, Vancouver, BC, Canada, forough.pourhossein@sauder.ubc.ca, Woonghee Tim Huh, Steven Shechter

We consider an assortment optimization problem in which consumers have a satisficing behavior rather than being utility maximizers. Satisficers do not necessarily investigate all items; they stop searching and make a purchase when an acceptability threshold is met. We incorporate search budgets in our optimization model too; customers leave without purchase if they are not satisfied with certain number of items they investigated. We prove our problem is NP-hard, demonstrate some structural properties and reformulate it as a MIP problem. We discuss the firm's expected revenue loss if they wrongly assume their consumers are utility maximizers or ignore search budgets.

■ WD77

S- Fremont

New Product Development

Contributed Session

Chair: Lili Shangguan, Xiamen University, Xiamen, 361005, China

1 - A Cooperative Game Based Method to Setting Target Values of Engineering Characteristics in Quality Function Deployment

Ping Ji, The Hong Kong Polytechnic University, Dept. of Industrial and Systems Engineering, Kowloon, Hong Kong, Yunwen Miao

Quality function deployment (QFD) is a systematic tool to mapping customer requirements (CRs) into engineering characteristics (ECs) in product design. In this paper, a mixed integer non-linear programming is established to determine target values of ECs to maximize overall customer satisfaction, whose objective is a Nash bargaining function among fulfillment degrees of CRs. These fulfillment degrees are expressed by a quantitative Kano's model. Finally, an example of a notebook computer design is used to demonstrate the feasibility and effectiveness of the proposed model.

2 - The Influence of Starting Configuration in Customer Co-design

Heejoo Lim, Korea University, Seoul, Korea, Republic of, hlim@korea.ac.kr

Customers can enjoy added value through co-design by possessing a unique product with a better fit reflecting their self-expression. While they might be confusing due to the complicated co-design process. The complexity level is differently perceived by different customers and it makes some of the potential customers give up to purchase a co-design product. Providing a starting configuration can attract them who are not accustomed to co-design of a certain product and the firm can avoid a situation to lose potential customers. This study analyzes the influence of starting configuration on the choice of process.

3 - Robust Product Line Design by Protecting the Downside While Minding the Upside

Tan Wang, The University of Texas at Austin, Austin, TX, United States, tanwang@utexas.edu, Genaro J. Gutierrez

Robustness approaches are useful when decisions must be made before uncertainties resolve. Two major approaches to robustness are: 1) maximizing the value of the worst outcome and 2) minimizing the ex-post regret of the decision made. We examine performance tradeoffs between the two approaches in the product line design problem, and we construct an efficient frontier for robust designs obtained by both approaches. Our findings indicate that it is possible to find robust designs that mitigate downside risk while limiting ex-post opportunity losses.

4 - Interactions Between Trade Promotion and Product Line Design under Demand Uncertainty

Yu Jiang, University of Science and Technology of China, Hefei, China, jiangyu1@mail.ustc.edu.cn, Jie Wu, Xiang Ji, Zhixin Chen

This paper studies a manufacturer's optimal decisions on trade promotion and product line design when the manufacturer sells through an independent retailer to uncertain market. The two major types of trade promotion, off-invoice and scan-back, are taken into consideration. We show that, when consumers have discrete demand uncertainty, a manufacturer may prefer scan-back to off-invoice no matter selling a product or a product line. In addition, a manufacturer can have more incentives to extend its product line when using off-invoice than scan-back in trade promotion.

5 - Drop-shipper or Re-seller: Analysis for Online Distribution Strategies with Demand Uncertainty and Off-line Retailing

Wei Lu, University of Science and Technology of China, Hefei, China, luw@mail.ustc.edu.cn, Jie Wu, Xiang Ji

We use a game-theoretical model to tackle the issue how the demand uncertainty and off-line retailing affect online distribution strategies. Our results show that the impact of online demand uncertainty on manufacturer's drop-shipping strategy is nonmonotonic. In addition, we show that both the manufacturer and the etailer prefers drop-shipping when aggressive off-line retailing exists.

6 - Manufacturer's Product Differentiation and Pricing Strategies in Different Channels

Lili Shangguan, Xiamen University, Xiamen, China, Yongquan Lan, Zhaowei Miao, Jiguang Chen

We learn how a manufacturer, who sells products through different channel, designs his product differentiation together with pricing strategies. By taking the horizontal and vertical dimensions of product differentiation into consideration, we divide the product differentiation strategies into four cases, establish game theory models for each case and derive related optimal pricing strategies. The results show when uniform/differentiated pricing strategies in different channel will be adopted under given product differentiation strategy and how the manufacturer designs his horizontal and vertical product differentiation strategies in different channels for given pricing strategy.

■ WD78

S- Greenwood

Big Data IV

Contributed Session

Chair: Yang Yang, Kellogg School of Management, Evanston, IL, 60208, United States

1 - People, Process and Products: An Analytical Perspective

Iddrisu Awudu, Quinnipiac University, Hamden, CT, United States, iddrisu.awudu@quinnipiac.edu, Mariama Yakubu

In this work, we consider a clinic access scheduling system in the US to be replicated in a Polyclinic in Ghana where patients (including pregnant women) wait for hours to be attended to by a healthcare provider. We consider two modeling frameworks from bed allocation/scheduling and optimization perspectives. We identify parameters that determine open clinic access and scheduling. We develop an optimization model using data for patient scheduling in an open clinic setting. We propose a novel solution to the proposed open clinic scheduling problem to reduce waiting times based on the data used. Finally, we outline the importance of decision support tool for patient scheduling in an open clinic setting.

2 - An Organic Web Intelligence Architecture Based on Micro-services and Data Processing Pipelines

Bram Steurtewagen, Ghent University, Ghent, Belgium, Bram.steurtewagen@ugent.be, Dirk Van den Poel

Keeping up with data streams on different media has become a challenge for researchers, communications experts and content producers alike. Web Intelligence tools tackle these vast amounts of data. In this study, we put forward an architecture based on the principles of micro-services, containers, and distributed frameworks in order to attain a media tracking platform. We show it possible to implement multiple trackers, analytics pipelines, and visualizations on one system that is fed by a common fabric. This allows for tracking viral phenomena over different media. In the study, we highlight the architectural fit of our proposal to data processing pipelines while being modular and scalable.

3 - The Emotional Response of the Public to the Development of Artificial Intelligence – Emotional Analysis Method Based on Microblog Text

Ma Liyi, Beijing Union University, Beijing, China, maryliyi@126.com

The existing studies on the impact of technological progress on employment effect mainly focus on phenomenal description, detail analysis and trend prediction, and there is no research that can accurately quantify the impact of the development of artificial intelligence (AI) on the public sentiment.Based on social media, this study builds a sentiment analysis model based on support vector machine using machine learning, sentiment analysis and other related methods, and carries out a quantitative evaluation on the psychological impact of artificial intelligence on the public, and finally verifies the effectiveness of this model.

4 - Research on Value Evaluation System of Online Literature Adapted for TV Drama

Dan Xiao, the Communication University of China, Beijing, China, Jinluan Ren

Based on the comprehensive analysis of the research status of online literature, this paper summarizes the factors that affect the value of online literature, and establishes the value evaluation system of online literature adapted for TV drama. On the basis of collecting 684 sample data, the weights of evaluation indicators are calculated by combined Analytic Hierarchy Process, experts scoring and entropy evaluation method. The value evaluation model of online literature adapted for TV drama is constructed and 18 samples are empirically analyzed and ranked according to content value, operational capability of publishing platform, derived value and comprehensive value respectively. This article provides a methodological support for selecting materials of TV dramas from online culture literature.

5 - Clinical Text Deidentification in the Era of Big Data

Ioana Danciu, Oak Ridge National Laboratory, Oak Ridge, TN, United States

Clinical notes offer invaluable insights into patients' health, but transforming the text into a research-ready form is no easy task. We present our approach to scrubbing billions of notes of protected health information (PHI) as defined by HIPAA. We used Apache Spark and worked with the National Library of Medicine (NLM) to adapt their PHI scrubber to our big data framework. The framework is generalizable to other natural language processing tasks. The results are supporting the Million Veterans Program (MVP) and are available to Veterans Affairs (VA) and Department of Energy (DOE) researchers.

6 - Media and Public Access to Science

Yang Yang, Kellogg School of Management, Evanston, IL, 60208, United States, Yuan Tian

Public opinion about science has become increasingly polarized in the past decade. While scientists are viewed central to scientific communication and literacy, we argue that the changing media environments play an increasingly important role in shaping public perception of science. We combined data of 160 million research articles, 63 million news reports, and 53 million tweets to describe how the mainstream media and the social media influence public access to scientific knowledge. We further address the causal impact of media using an IV2SLS approach.

■ WD79

S- Issaquah A

Energy VI

Contributed Session

Chair: Hao Ding, Nanjing University of Aeronautics and Astronautics

1 - Does Clean Heating Improve Air Quality? Evidence from Chinese Cities

Tong Feng, Tianjin University, China, Tianjin, China, fengtong@tju.edu.cn, Huibin Du, Ning Zhang

To improve the air quality in winter, clean heating policy was implemented in "2+26" pilot cities of China in 2016. Using a difference-in-differences method, we estimate the impact of clean heating policy on air quality. We find this policy improves the daily air quality index by 6% and increases the number of days with good air quality. The health and economic co-benefits of clean heating are huge. We also find the consumption growth of clean coal does not lead to the deterioration of air quality. There is suggestive evidence revealing the advanced coal-fired boilers for heating will be helpful for air quality improvements. It is more in line with China's coal-rich and gas-short resource endowment.

2 - Quantitative Evaluation of the Feasibility of Meeting Emission Targets with a Chance Constrained Energy System Model

Hansung Kim, Pohang University of Science and Technology (POSTECH), Cheongam, Pohang, Korea, Republic of, willhomehs@postech.ac.kr, Hyungkyu Cheon, Daeho Kim, Dong Gu Choi

Recently, researchers have incorporated uncertainties into energy system models with stochastic programming-based models. Most studies focused on meeting greenhouse gas (GHG) reduction targets considering various uncertainties. However, meeting targets leads to dramatic cost increases. At the same time, there is a risk to fail to meet the targets if enough uncertainties are not considered. Therefore, it is important to find a balance between cost and risk. In this study, we define the risk as to the feasibility of meeting GHG reduction targets and evaluate the risk by using a chance-constrained model. We apply the model to South Korea and analyze the trade-off between total cost and the risk.

3 - Optimal Management of a Demand Response Aggregator in a Small-scale Electricity Market

Jong-hyun Ryu, Hongik University, Sejong, Korea, Republic of, jhryu@hongik.ac.kr

Demand response (DR) resources have been more discussed as grid flexibility becomes more important. In order to cost effectively manage scattered DR resources in a small-scale electricity market, a DR aggregator needs to determine an optimal operating policy. This study develops an optimization model for a DR aggregator. To promote DR programs, we also provide a guideline on designing an effective subsidy policy considering the uncertainty of market prices and balancing requirements.

4 - A Bi-level Program Approach to Utility Estimation for Price-responsive Electricity Consumers

Arnab Roy, University of Louisville, Louisville, KY, United States, arnab.roy@louisville.edu, Lihui Bai, Bo Zeng

We present a bi-level optimization model for estimating utility parameters for price-responsive electricity consumers in a demand response environment. The lower level problem is for the user to maximize his/her total utility by determining the optimal curtailed load daily on multiple event days. The upper level problem minimizes the difference between the optimal consumption induced from the lower level and the actual consumption data by determining proper utility parameters. Computational results on the model and a fast trust-region algorithm will be reported.

5 - Dynamic Programming Model for Optimal Policy Supports Driving Renewable Energy Technology Development

Hao Ding, Nanjing University of Aeronautics and Astronautics, Nanjing, China, dding2009@nuaa.edu.cn, Dequn Zhou, Peng Zhou

Renewable energy technologies (RETs) are undergoing rapid developments globally. One of the main contributors is policy supports. The expenditure and efficiency of policy supports have to be considered with such a great market scale for RETs. This study aims to offer a model to search optimal policy supports for RETs integrating forces of technology push and demand pull. A dynamic programming model with the objective of minimizing policy expenditure is constructed. The results show that policy supports would be the main force for RETs' developments during their initial development periods. Policy supports should be reduced faster than the cost decline in order to improve their efficiency.

■ WD80

S- Issaquah B

Simulation II

Contributed Session

Chair: Jing Ma, Nanjing University of Aeronautics and Astronautics

1 - An Agent-based Model of Miscommunication in Complex System Engineering Organizations

John Meluso, PhD Candidate, University of Michigan, Ann Arbor, MI, United States, jmeluso@umich.edu, Jesse Austin-Breneman, Lynette Shaw

A recent study of a Fortune 500 firm demonstrated widespread "miscommunication"—communication with deficient outcomes—about the definition of "an estimate" in complex system design. We show via agent-based model and Monte Carlo simulation that design process miscommunication may affect system performance. Each run created and designed a unique 1000-artifact system through generative networks and optimization. Systems employing "current" design estimates outperformed "future" design projections ($p<0.001$). Fractional usage of each definition varied system performance and uncertainty. With estimates and generally, organizational miscommunication may affect system performance.

2 - Simulation-based Queueing Inference of the True Arrival, Balking, and Reneging Processes from Censored Transactional Data

Ashkan Negahban, Assistant Professor, The Pennsylvania State University, Malvern, PA, United States

Transactional data collected on queueing systems often censor unsuccessful arrivals due to balking and/or unserved entities due to reneging. In many situations, the true arrival, balking, and reneging events are unobservable, making it virtually impossible to collect data on these stochastic processes - information that is crucial for capacity planning and process improvement decisions. In this work, the estimation problem is formulated as an optimization model and an iterative simulation-based inference approach is proposed to find appropriate input models for these stochastic processes. The efficacy of the proposed approach is illustrated in a real-world application in a call center.

3 - A Data-driven Simulation Platform of Microscopic Road Behaviors and Macroscopic Traffic Flows

Cong Zhao, Roman Roads, Inc, San Jose, CA, United States, czhao27@wisc.edu

Carmakers and traffic regulators are faced with issues of decision making in operation and planning and it can be alleviated by utilizing a simulated environment. AI technologies can be leveraged to address issues of system modeling of driver's intention and behaviors, traffic capabilities. The speaker presents that have been used to build and train an AI-powered simulation. Data-driven approaches are exploited to learn real human road behaviors and produce simulated traffic scenes, trajectories, and intentions of road users. System-level architectures are also described on how to take into account the correlations among the road users in macroscopic traffic flow simulations.

4 - Rumor Spreading in Online Social Networks by Considering the Group and Individual Differences

Jing Ma, Nanjing University of Aeronautics and Astronautics, Nanjing, China, Chi Li, He Zhu, Xiaoyu Guo, Jiao Yan

In this study, we explore the impact of the group and individual differences on the rumor spreading process. Under the basis of the mean-field theory, we formulate the mathematical expression of the rumor spreading model, and theoretically analyze the spreading threshold. With the help of the Monte-Carlo simulation method, the theoretical analysis is explicitly verified. According to the numerical simulation, we find that the final density of spreaders is in positive correlation with both the group and individual difference coefficients. However, the impact of these two factors are not the same: the effect of the group difference is more significant.

■ WD81

S- Kirkland

Process Engineering and Energy

Contributed Session

Chair: Martin M Spollen, Queens University Belfast, Belfast, BT9 5JX, United Kingdom

1 - Relationships in Heart Rate Variability Measures and Their Ability to Predict Physical Performance

Michael Tolston, Ball Aerospace and Technologies, Fairborn, OH, United States, mtolston@ball.com, Nickolas Mackowski, Maegan O'Connor, Adam Strang

The ubiquity of wearable heart rate monitoring devices has both simplified the collection of heart rate data and added confusion regarding the large number of proprietary algorithms related to heart rate variability (HRV). In this work, we show how some of these proprietary metrics are related to traditional measures of HRV and compare their ability to predict performance in strenuous physical activities. We show that various metrics are related in predictable ways and that traditional metrics of HRV can be used to predict performance outcomes in repeated measures data.

2 - Can Learning-by-doing Hurt Profit? The Case of Outsourcing and Supplier Encroachment

Yaqin Sun, Drexel University, Philadelphia, PA, United States, ys523@drexel.edu, Wenjing Shen

In this paper we consider an OEM's outsourcing decision when CM can learn to reduce production cost and when CM can enter the market. We want to study how this learning affects CM's encroachment decision. We will further discuss how OEM adjusts its outsourcing quantity when CM can encroach the end market.

3 - Application of Data Science Techniques to Transform Public Investment Management

Martin M. Spollen, Queens University Belfast, Belfast, United Kingdom, m.spollen@qub.ac.uk

This session will examine the development and application data science techniques for consumer choice analysis to inform public investment management. These approaches focus attention on the network effects of investment on total portfolio performance. Application to a major regional schools investment and rationalisation programmes is demonstrated.

■ WD82

S- Leschi

Joint Session ENRE/ MSOM: Environmental Management

Sponsored: Energy, Natural Res & the Environment/Environment & Sustainability

Sponsored Session

Chair: Sriram Narayanan, Michigan State University, East Lansing, MI, 48824, United States

Chair: Troy Tong, Tsinghua University, Tsinghua University, China

1 - Predicting Carbon Abatement Outcomes Using Text Analysis

Christian Blanco, Ohio State University, 640 Fisher Hall, 2100 Neil Ave, Columbus, OH, 43210, United States, blanco.58@osu.edu

Are firms strategic in disclosing carbon emissions reduction projects? We explore this question by comparing carbon emissions reduction projects with partial and full information. We use data from over 40,000 carbon abatement opportunities reported to CDP from 2011-2016.

2 - Administrative Environmental Innovations, Supply Network Structure, and Environmental Disclosure

Marcus A. Bellamy, Boston University, Rafik B. Hariri Building, 595 Commonwealth Avenue, Boston, MA, 02215, United States, bellamym@bu.edu, Suvrat Dhanorkar, Ravi Subramanian

Using supply chain relationship (SPLC) and environmental, social, and governance (ESG) data from Bloomberg, we test our hypothesized relationships between focal firms' adoption of administrative environmental innovations and their extent of environmental disclosure, with supply network structure as a moderating factor.

3 - How Resource Scarcity Affects Environmental Performance?

Suresh Muthulingam, The Pennsylvania State University, Smeal College of Business, 460 Business Building, University Park, PA, 16803, United States, Charles J. Corbett, Suvrat Dhanorkar

Using econometric techniques, we examine the impact of resource scarcity on the environmental performance of Texas manufacturing plants.

4 - An Analysis of Subsidy Policies for the Adoption of Electric Vehicles

Runyu Tang, Tsinghua University, Beijing, China, try15@mails.tsinghua.edu.cn, Saed Alizamir, Foad Iravani

Electric vehicles(EV) are good alternatives to the traditional gas vehicles in case of reliving global warming. Governments around the world try to promote EV adoption and develop EV infrastructures to protect the environment. The charging station deployment has a strong network effect on EV consumers, so the government needs to distribute the subsidy to the EV consumers and to charging station investors efficiently to boost the adoption process. We construct an analytical model which capture the network effect and the government's cost-benefit trade-off, and and the optimal subsidies structure under different scenarios.

5 - Impact of Geographic Water Stress on Operational Sustainability

Dustin Cole, Michigan State University, Sriram Narayanan, Elizabeth Connors

We examine the impact of geographically local water stress on operational sustainability, focusing on reduction in greenhouse gases, water and solid waste in operational outcomes. Using context theory we theorize that having water stress occur in the geographic area around the organization will provide a number of contextual cues that will cause the organization to improve the sustainability of its operational outcomes.

■ WD83

S- Medina

Voltage and Transient Stability in Modern Electric Power Systems

Sponsored: Energy, Natural Res & the Environment/Electricity

Sponsored Session

Chair: Andy Sun, Georgia Institute of Technology, Atlanta, GA, 30332-0205, United States

1 - Stability Properties of the Equilibrium Points in Power System Swing Equations

Amin Gholami, Georgia Institute of Technology, Atlanta, GA, 30080, United States, Andy Sun

Swing equations are a set of ordinary differential equations that model the dynamic behavior of power grids. Although swing equations have been extensively used in various contexts such as transient stability assessment for a long time, several basic questions on the stability of these equations have still remained unanswered. In particular, when a power system with nontrivial transfer conductances is stable? What is the relation between the underlying graph of a power system with the stability of its equilibrium points? In this talk, we address these questions. Moreover, we present a set of sufficient and necessary conditions for power system transient stability.

2 - Model-free Real-time Optimal Power Flow for Voltage Regulation

Andrey Bernstein, NREL, 15013 Denver West Parkway, Golden, CO, 80401, United States, andrey.bernstein@nrel.gov

We consider the problem of real-time optimal voltage regulation in distribution network with high penetration of distributed energy resources (DERs). Classic approaches rely on solving optimal power flow (OPF) that requires accurate network model. In high-penetration scenarios, this approach might fail to address system uncertainties. We propose a model-free algorithm that optimizes grid objectives using real-time measurements. It uses a quasi-stochastic approximation approach to estimate the gradients and solves the OPF by a gradient-based approach. It is adaptive to variable conditions, such as topology reconfigurations, faults, and variability of renewables.

3 - Towards Robustness Guarantees for Feedback-based Optimization

Marcello Colombino, McGill University, Montreal, QC, Canada

Feedback-based optimization algorithms for real-time optimization of the distribution grid have gained traction in recent years because of their simple implementation, their ability to reject disturbances in real time, and their increased robustness to model mismatch. In this work, we propose a framework to systematically assess the robust stability of feedback-based online optimization algorithms. We leverage tools from monotone operator theory and classical robust control to obtain tractable numerical tests that guarantee robust convergence properties of online algorithms in feedback with a physical system, even in the presence of disturbances and model uncertainty.

4 - Optimization of System-level Performance and Resilience of Low-inertia Power Systems

Dominic Gross, ETH Zurich, Zurich, Switzerland

A consequence of the transition of power systems towards renewable generation is the loss of synchronous machines, their inertia, and frequency and voltage control mechanisms. This leads to critical challenges in maintaining system stability. This talk focuses on system norms as metric for transient stability, resilience, and performance. In particular, system norms can be use to obtain efficient optimization algorithm that can be used to optimize the placement and control parameters of power converters provide frequency and voltage regulation in in large-scale systems.

5 - Solvability of Power Flow Equations Through Existence and Uniqueness of Complex Fixed Point

Bai Cui, Argonne National Laboratory, , Lemont, IL, 60015, United States, bcui@anl.gov

Despite intensive study, some basic properties of power flow equations still remain elusive. In particular, under what condition these equations admit a solution is one of the most fundamental questions. This question bears great theoretical and practical significance as it is intimately related to the stability of largescale power grids. In this presentation, we provide a strong solution to this question by identifying a sufficient condition to certify the existence and uniqueness of power flow solutions. Our novel approach exploits a certain fixed-point form in the complex domain, which leads to much sharper conditions than previously achievable through analysis in the real domain.

■ WD84

S- Ravenna A

Advanced Game-theoretic Models in Energy Systems

Sponsored: Energy, Natural Res & the Environment/Energy Sponsored Session

Chair: Jalal Kazempour, Technical University of Denmark, Kgs Lyngby, 2800, Denmark

Co-Chair: Spyros Chatzivasileiadis, Technical University of Denmark, Kgs. Lyngby, 2800, Denmark

1 - Market Design for Peer-to-peer Energy Trading and Distribution System Flexibility

Thomas Morstyn, Research Fellow, University of Oxford, Oxford, United Kingdom, thomas.morstyn@eng.ox.ac.uk

Power systems are undergoing a fundamental transition, due to the emergence of distribution network 'prosumers', proactive consumers with flexible energy resources and ICT infrastructure who actively manage their consumption, production and storage of energy. Networked matching market theory is proposed for designing decentralised digital market platforms that allow prosumers to engage in peer-to-peer energy trading, and offer flexibility services to their local distribution system operator. The proposed market designs allow prosumers to reach agreement on a set of economically efficient and game theoretically stable transactions.

2 - When Nash Meets Stackelberg

Sriram Sankaranarayanan, Polytechnique Montreal, Montreal, QC, Canada, sriram.sankaranarayanan@polymtl.ca, Felipe A. Feijoo, Andrea Lodi

We provide an algorithm to compute a mixed-strategy Nash equilibria of a Nash game where each player's (or leader's) pay off is given as a bilevel linear program. This leads to a situation where the leaders not only play a Nash game with other leaders but also a Stackelberg game with their own follower(s). The algorithm exploits the polyhedral structure in the game and our ability to solve mixed-integer linear program fast. We then use this model to solve for equilibrium in a Nash game among countries (leaders) where each country also plays a Stackelberg game with their indigenous industries (followers).

3 - Efficiency of Two-settlement Electricity Markets under Alternative Market Designs and Oligopolistic Conduct

Puneet Chitkara, Post Doctoral Fellow, Johns Hopkins University, Baltimore, MD, United States, puneetchitkara2903@gmail.com, Benjamin Field Hobbs, Jalal Kazempour, Kaiying Lin

This study seeks to assess the efficacy of flexible resources, including fast-start generators and demand response and financial participants (virtual bidders) in enhancing the efficiency of two-settlement electricity markets under alternative market designs and conduct of market players with different risk perceptions. The simulations are done on large real-world power systems using Alternative Directions Method of Multipliers (ADMM). The work is proposed to be an extension of Kazempour and Hobbs (2018) and Kazempour and Pinson (2016).

4 - Risk Trading in Energy Communities

Niklas Vespermann, PhD Student, Technical University of Munich, Munich, Germany, Jalal Kazempour, Thomas Hamacher

Volatile local market-clearing prices give rise to heterogeneous risk preferences of community members. To prevent welfare losses due to conservative trading decisions in the forward stage of a few highly risk-averse players, we propose risk trading in energy communities. The Conditional Value-at-Risk serves as our risk measure for players to study different degrees of risk market completeness. For incomplete risk markets we formulate a two-stage stochastic equilibrium problem, while relaying on optimization when the risk market is complete. Results indicate that system costs savings can be realized when players engage in risk trading and sufficient financial products are available.

5 - Electricity Market Equilibrium under Information Asymmetry

Vladimir Dvorkin, PhD Student, Technical University of Denmark (DTU), Kgs. Lyngby, 2800, Denmark, Jalal Kazempour, Pierre Pinson

We study a competitive electricity market equilibrium with two trading stages, day-ahead and real-time. The welfare of each market agent is exposed to uncertainty associated with renewable energy production, while agent information on the probability distribution of this uncertainty is not identical at the day-ahead stage. We show a high sensitivity of the equilibrium solution to the level of information asymmetry and demonstrate economic, operational, and computational value for the system stemming from potential information sharing.

■ WD85

S- Ravenna B

Machine Learning for Energy System Operations

Sponsored: Energy, Natural Res & the Environment/Energy Sponsored Session

Chair: Yue Zhao, Stony Brook University, Stony Brook, NY, 11794, United States

Chair: Baosen Zhang, University of Washington, Seattle, WA, 94105, United States

1 - Learning to Infer Voltage Stability Margin using Transfer Learning

Yue Zhao, Stony Brook University, Stony Brook, NY, 11794, United States, yue.zhao.2@stonybrook.edu, Jiaming Li, Young-hwan Lee, Seung-Jun Kim

Preventing voltage collapse is critical for reliable operation of power systems. A challenging problem is that the voltage stability margin is very computationally intensive to obtain. A novel machine learning-based approach for real-time inference of voltage stability margin is developed, only needing a very small number of offline-computed voltage stability margin data. An accurate margin predictor is trained by first training a binary stability classifier and then transferring this pre-trained model to fine-tune on the small data set of margins. Numerical simulations demonstrate the superior performance of the proposed method.

2 - Optimal Transmission Switching under Uncertainty using Linear Decision Rule

Yuqi Zhou, The University of Texas at Austin, Austin, TX, United States, zhouyuqi@utexas.edu, Hao Zhu, Grani Adiwena Hanasusanto

Transmission switching is becoming a popular operational strategy for interconnected power systems to reduce congestion and generation costs. With growing level of renewable energy sources such as wind generation, it is of increasing importance to account for the uncertainty in power system operational tasks including transmission switching. We will present a two-stage stochastic mixed-integer programming formulation for the optimal transmission switching (OTS) problem using sample scenarios of random wind power. The technique of linear decision rule is leveraged to solve the proposed two-stage problem to accelerate the computational speed.

3 - Kernel-based Learning for Inverter Control Rules

Manish Singh, Virginia Tech, Blacksburg, VA, United States, Mana Jalali, Vassilis Kekatos

Smart inverters have been advocated as a fast-responding mechanism for voltage regulation in distribution grids. Nevertheless, optimal inverter coordination can be computationally demanding, and preset local control rules are known to be subpar. Leveraging tools from machine learning, the design of customized inverter control rules is posed here as a multi-task learning problem. Each inverter control rule is modeled as a possibly nonlinear function of local and/or remote control inputs. The function outputs interact to yield the feeder voltage profile. Inverter rules are designed jointly to minimize a voltage deviation objective based on anticipated load and solar generation scenarios.

4 - Power System Control and Decision-making via Deep Reinforcement Learning

Qiuhua Huang, Sr. Research Engineer, Pacific Northwest National Laboratory, Richland, WA, United States, qiuhua.huang@pnnl.gov

In this talk, Dr. Huang will first talk about reinforcement learning, particularly deep reinforcement learning (DRL), and how it could be applied to address some of critical control and decision-making problems in power systems. Reinforcement Learning for Grid Control (RLGC), an open-source platform for development and benchmark reinforcement learning algorithms for grid control, was developed. Experiments on generator dynamic braking and undervoltage load shedding problems show the adaptiveness and robustness (to uncertainties and noise) of the developed DRL-based control schemes, compared with conventional Q-learning, model predictive control and existing protection mechanisms.

5 - Learning Congestion Patterns in AC Optimal Power Flow

Line A. Roald, Assistant Professor, University of Wisconsin, Madison, WI, 87544, United States, roald@wisc.edu, S idhant Misra, Yee Sian Ng

In power systems operation, similar optimization problems are solved over and over and over again, with only slight variations in load and system topology. Interestingly, in many power system test cases, there seems to be only a limited number of limiting constraints (so-called active sets) that determine the optimal system operation - even across a wide range of operating conditions. Even more strikingly, only a few constellations of congested transmission corridors seem to be relevant to practical system operations. In this talk, I will discuss our work on learning active sets, active constraints and transmission congestion patterns in optimal power flow problem.

6 - Networked Synthetic Dynamic PMU Data Generation: A Generative Adversarial Network Approach

Dileep Kalathil, Texas A&M University, College Station, TX, United States, Xiangtian Zheng, Dongqi Wu, Le Xie

Due to the confidentiality of real PMU data and no public access to detailed real power systems model, the lack of credible PMU data becomes a growing concern for research and education purposes. In this paper, using partial power systems infrastructure information, we develop a GAN-based method to synthesize realistic networked PMU data, which satisfy basic physics laws and mimic dynamic behavior of simulated power system. We validate the realistic dynamic characteristics of networked synthetic PMU data via a modal analysis method.

■ WD86

S- Ravenna C

E Business/Commerce III

Contributed Session

Chair: Orcun Temizkan, Ozyegin University, Cekmekoy Kampusu, Istanbul, 34794, Turkey

1 - How Shall I Trust the Online Review Through the Different Channels? An Empirical Study in Australia B2C Marketplace

Cong Cao, Tutor, University of Wollongong, Wollongong, Australia, cong.cao@outlook.com, Jun Yan, Mengxiang Li

Due to the virtual nature of e-commerce, trust plays an indispensable role. Furthermore, viewing other consumers' reviews and information becomes an effective risk control method for consumers. In order to better understand its influence mechanism on consumers' trust intention, based on related research, this paper summarizes the definitions of online review and then discusses in detail the meaning of the channel of online review and the different channels. Moreover, with the experimental method and data analysis, this paper substantiates that online reviews perceived by consumers from different channels have a significant difference and further demonstrate the existence of heterogeneity.

2 - Strategies for Online Retailers to Counter Webrooming

Peng Wang, Xidian University, Xian, China, wangpeng7@stu.xidian.edu.cn, Zhe Zhang

Webrooming (searching for information online and ultimately purchasing products offline) has been recently witnessed in multi-channel retailing. We develop a game theoretic model to examine how webrooming affects the profits of online retailers. We find that the existence of webrooming reduces the online retailer's profit. We also reveal that the product exclusive strategy is available for online retailers to counter webrooming. Finally, we extend to consider the strategic role of the manufacture and find that the product exclusivity strategy can generate a win-win outcome.

3 - Analysis of Online Arbitrage and Increased Returns

Avinash Geda, University of Florida, Gainesville, FL, United States, Jingchuan Pu, Liangfei Qiu

We model the phenomenon of online arbitrage and the associated problem of increased returns in a game-theoretic setting. We propose a solution to alleviate this problem and analyze how consumer surplus is affected under different settings.

4 - Integrating Kansei Engineering Into Analysis of Customer Requirements from Online Opinions

Jian JIN, Beijing Normal University, Beijing, China, jinjian.jay@bnu.edu.cn, Danping JIA, Qian Geng, Ping Ji

Designers have to optimize products according to customer requirements (CRs). Besides functional features, products need to meet emotional aesthete designs and it is critical for designers to understand emotional CRs. To capture emotional CRs, in this study, Kansei engineering is integrated with the Word2vec model. It helps to generate a domain Kansei lexicon and a product feature dictionary. Also, a feature-Kansei model is developed to represent CRs. To evaluate the effectiveness, an empirical case study is conducted with phone reviews. It shows that the integration of Kansei engineering helps to capture emotional CRs from online opinions and provides more critical insights for designers.

5 - Understanding Quality of Crowdsourced Answers in Online Communities

Orcun Temizkan, Ozyegin University, Istanbul, Turkey, orcun.temizkan@ozyegin.edu.tr, Ram Kumar

Community-based question answering is becoming increasingly important for the ability of online crowdsourcing community to generate quality answers to questions. Crowdsourcing answers to questions represent online knowledge repositories. In this respect, the quality of answers is important. Therefore, we present a model to understand factors that influence the quality of a good answer using theories from the knowledge management, multitasking, and social networks literatures. Empirical results based on data from a crowdsourcing website (Stack Overflow) will be presented.