FRAUNHOFER CENTER FOR MANUFACTURING INNOVATION

The PiezoImplant system

The Fraunhofer Center for Manufacturing Innovation (CMI), together with its partners, Boston University and the Fraunhofer Institute for Production Technology, conducts advanced research and development leading to engineering solutions for a broad range of industries, including biotech/biomedical, photonics, and renewable energy. Fraunhofer engineers, faculty and students scale up basic research into advanced technologies for client companies in the U.S. and abroad. CMI's primary focus is on next-generation, high-precision automation systems as well as medical devices and instruments that lie at the intersection of engineering and biology.

Last year was CMI's most successful year, both financially and technologically. In the life-sciences area, during 2014, CMI has worked on a number of NIH-funded projects, including "Rapid Antibiotic Susceptibility Testing," "Bacterial Drug Susceptibility Identification by Surface Enhanced Raman Microscopy," and "NIH Center for the Future Technologies of Cancer Care." In addition, CMI also worked on an NSF-funded project, "Charge-Assisted Protein Sensing." CMI continues to establish itself as a key player in the biotech/biomedical areas with the U.S. government funding agencies.

On the industrial front, CMI has acquired repeat business from industry leaders, as well as new key $1M+ accounts from major U.S. and multi-national corporations. Also, as a "preferred vendor" of the US Mint, CMI acquired a new a project to develop alternative technologies for making coins (money).

Finally, CMI has further enhanced its reputation in the scientific community with several journal publications in 2014.

Representative Projects at CMI during 2014 included:

Technology Evaluation Study for a Large Metal Container Manufacturer

Fraunhofer CMI partnered with Fraunhofer IPT, its parent institute in Aachen, Germany to evaluate manufacturing practices of a large metal container manufacturer and propose new technologies that will improve production efficiency, quality, and cost. In addition, Fraunhofer facilitated a technology innovation session for executives from the company. The initial process consisted of on-site visits to several of the client's large manufacturing operations, each with multiple different production lines. The production processes were evaluated and potential areas of improvement noted. Line managers were interviewed to contribute their experiences and provide productivity, reliability, and capacity data. Fraunhofer distilled that information and researched state-of-the-art technologies and novel concepts that might yield either incremental or game changing results. Each idea was developed into a Technology Data Sheet to be reviewed with the client.

Fraunhofer then guided an Innovation Session with the company leaders. The innovation session started with review of the Technology Data Sheets proposed by Fraunhofer, and then continued with the company leaders contributing their own ideas to the list of possibilities. All the ideas were ranked according to the potential impact as well as fit into the client's production processes. This drove a down-selection process to focus on a few key ideas that are currently being pursued in follow-on projects.

Novel Dental Implants

Tooth loss leads to local resorption of the jaw bone. The longer the tooth is missing, the more bone is lost. When using dental implants, bone augmentation with cadaver bone is the most common solution to

enlarge the jawbone at the desired implant site. More than 50% of patients require bone augmentation before or during dental implant placement.

The PiezoImplant system, jointly developed by the Fraunhofer CMI and the Boston University Dental School, is based on the concept that the implant should match the shape of the available bone, thus eliminating the need for bone augmentation. A piezotome is a miniature bone saw vibrating at ultrasonic frequencies and sub-millimeter amplitudes. The piezotome is capable of creating various shapes of non-round cuts, thus for narrow bone ridges narrow bone cuts can be made and flat implants may be precisely fitted. The non-round nature of the newly developed implants allows for a stronger implant to be placed into the narrow ridge of the recessed jaw bone.

During the design of the piezotomes, CMI employed advanced finite element and modal analysis tools to match the natural frequency of the piezotome tool to that of the instrument. A number of successive tools were developed to facilitate the step-by-step shaping of the implant site, beginning with a traditional round drill, continuing with a course roughing tool and finishing with a fine finishing tool. Prototypes for both implants and piezotomes have been fabricated and tested. The PiezoImplants were examined with respect to fatigue and stress distribution during and after placement. In vivo testing is currently in progress to assess the integration and functionality of the PiezoImplant. This is accomplished by placing PiezoImplants in the mouth of mini pigs and monitoring the success of the implant.

Laser Eye Scanner for Early Detection of Alzheimer's Disease

Alzheimer's disease (AD) is the leading cause of death in the United States. Unfortunately, there currently is no cure or even a means of slowing down the disease. Despite numerous drugs in development, and numerous clinical trials, the disease remains incurable once it become symptomatic. To be effective, therepeutic treatment must be initiated before the appearance of cognitive symptomos and irrevrsible brain damage. Thus, early detection is the key to a cure, and has been recognized as a national healthcre priority.

Fraunhofer CMI and Boston University have engineered an innovative laser eye scanner that enables noninvasive detection and tracking of AD-linked pathology in the lens of the eye, which is present and detectable even at the presymptomatic stage. It has been shown that accumulation of β-amyloid peptides (Aβ) in the brain and in the lens of the eye is linked to AD. While detection of accumulation of AD-linked Aβ in the brain may be too late within the window of effective treatment, the accumulation in the lens of the eye can be detected early using special purpose confocal laser opththalmoscopes with quasi-elastic scattering (QLS) autocorrelation spectroscopy. This technology has been developed and validated by Boston University, using a proof-of-concept system, over the past several years.

In this project, CMI and Boston University developed the first-generation clinical instrument suitable for clinical testing on human subjects. This full-function, user-friendly instrument will be deployed in a multi-center clinical trial in the coming months.

Sheet Metal Forming Using High Speed, Automated Hammering

Traditionally, sheet metal may be formed into various shapes by hammering the metal on various anvils. This labor intensive, physical process requires master craftsmen

Laser Eye Scanner for Early Detection of Alzheimer's Disease

Automated High-Speed Hammering Machine

and is normally only suited to low volume production or prototype work. As products transition to higher volume, stamping dies are fabricated to greatly speed the process and reduce cost in quantity. However, there are some products which can benefit greatly from the unique metallurgy that is produced by individual hammer strikes. Applying automation to this labor intensive process has been difficult due to the wide variation in the size, shape, and weight of products that are manufactured. The different hammer patterns require a flexible holding system to allow nearly all of the sheet metal surface to be reached. Furthermore, the hammering can cause some metal to deform in process in an unpredictable way. This form is corrected in subsequent processes, but an automated hammering system must accommodate this changing shape.

Fraunhofer CMI has developed a new impact hammer system for the production of a wide variety of sheet metal shapes. Two impact hammers are incorporated into a workcell serviced by one loading robot. The workcell allows unattended processing, with the robot loading incoming metal blanks from material handling carts, and outputting processed parts on similar carts. The hammers themselves use a high performance hydraulic ram system for the hammering action. The hammer can cycle in excess of 10 strikes per second, limited by the amount of positioning required between each strike. Interchangeable anvils can provide different hammering characteristics. The hammering force is programmable, as are all crucial process parameters such as the pattern and metal thickness. The operator needs to only select the appropriate program from a menu of choices. Manipulation of the sheet metal blank is accomplished with a robust, multi-axis positioning system using linear and rotary axes to provide full access to the metal surface for multiple shapes while withstanding the intense vibration and

forces of the hammering operation. The workcell successfully processes the products while greatly reducing the required labor.

Artificial Hand for Minimally Invasive Surgery

Over the past several decades, minimally invasive surgery has become more prevalent because it does not require major incisions to the patient, allows for quicker healing, reduces post-operative pain, and may reduce wound complications. However, in comparison to open surgery, existing laparoscopic tools still limit the surgeon's dexterity significantly. In contrast, during open surgery or hand-assisted laparoscopic surgery, the surgeon has the ability to easily grasp, retract, and manipulate organs as necessary. Typically, the surgeon's non-dominant hand is used mainly to retract, palpate, and expose tissue, while the dominant hand manipulates instruments to conduct surgical dissection.

Laparoscopic, single incision, natural orifice and robotic approaches each hold their own appeal. However, they lack the ability to manipulate organs as easily as the human hand. Advances in minimally invasive surgical techniques require new tools with increased functionality of the end effectors. Multifunctional tools with greater dexterity than those currently available are highly desired.

To address this need, CMI designed, fabricated, and tested the first prototype of a laparoscopic tool that provides the dexterity of a hand. The "hand" has two jointed fingers and a jointed thumb attached to a laparoscopic sheath that can be collapsed to fit through a 12 mm trocar or small orifice. The handle provides control for three independent degrees of freedom: finger motion (bending/spreading), finger tip bending, and thumb bending. The tool can be used for pinching, grasping, and spreading motions. Furthermore, the thumb is "double jointed" so that the tool can be converted to a rake configuration to allow lifting motions. The initial prototype has been tested in a cadaver lab to demonstrate its utility. The "Lap-Hand" was used to complete standard surgical tasks in a simulation device in a time comparable to open and laparoscopic approaches, including "bowel" manipulation and peg movement. Cadaver testing confirmed the ability to grasp, elevate and move liver, stomach, colon and small bowel in a fashion expected by the hand. During the cadaver testing, various surgeons tested the device for its ability to grasp, elevate and move liver, stomach, colon and small bowel. Three surgeons, who had not had any prior training in its use, tested the device. No adverse events were noted and no bowel injury or perforation resulted from over-grasping. Use of such tools could both reduce the number of hand-incisions required and potentially transition more patients to undergo their abdominal procedures laparoscopically.

CMI Internship Program

CMI's internship program continues to thrive, providing a global experience to 12 interns per year. Since its inception, the program has hosted over 150 interns, mostly from Europe. Interns are provided with housing and a stipend, and are encouraged to experience not only the American workplace, but the American culture as well. The program has been tremendously successful, receiving rave reviews from all involved. These students are subsequently highly recruited in Europe, as they bring a global perspective to the job.

For more information:
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