Intelligent Dynamic Noise Reduction (iDNR) Technology

Innovative technologies found in Bosch HD and Megapixel IP cameras can effectively reduce network bandwidth requirements and subsequent storage costs, while maintaining high quality and detailed images.

Cost-saving technologies

Megapixel cameras deliver ultra-detailed images with more useful information – but this comes at a cost. The volume of data required to transport and store these images has risen significantly. The bandwidth demands that this places on the network infrastructure and the increase in required storage capacity adds significantly to total IP system costs. Disk space is one of the most expensive components of IP systems. Higher storage costs can ultimately cost you the difference of winning the next large project.

The best place to reduce these costs is at the source – in the camera. And this is where Bosch takes a multi-pronged approach to reducing the quantity of data while retaining high quality of image:

- Content-based Imaging Technology (CBIT) to reduce noise
- Region prioritization to target important information
- Optimized encoder efficiency to increase compression ratios

The combination of these technologies has a significant impact on the bit rate/quality ratio which is directly proportional to storage and network costs.

CBIT – the key to noise reduction

Noise is a random pattern of pixels visible in the image. Some degree of noise is always present in any electronic device that transmits or receives a signal. Image noise is an undesirable by-product of image capture and the most detrimental factor in clogging the encoding process which leads directly to exaggerated bit rates for a given image. Megapixel cameras are more susceptible to noise as the pixels on the sensor are smaller and are not able to collect as much light. More amplification is required which introduces noise. Low-light scenes also contribute to an increase in noise levels.

A first in the security industry, Bosch introduces a new technology for controlling the image processing. Content-based Imaging Technology (CBIT) is an intelligent scene analysis system that examines the actual content of the video image and provides feedback to the digital signal processor (DSP) to re-tune the image processing.

Bosch is the only security camera manufacturer with full control over image processing with intelligent video analysis (IVA) and Motion+. With this ground-breaking platform CBIT enables the sensors, the image processing and IVA to work as one module. CBIT radically improves the image quality in many areas but also has considerable impact when used to reduce noise.

Content-based Imaging Technology (CBIT)
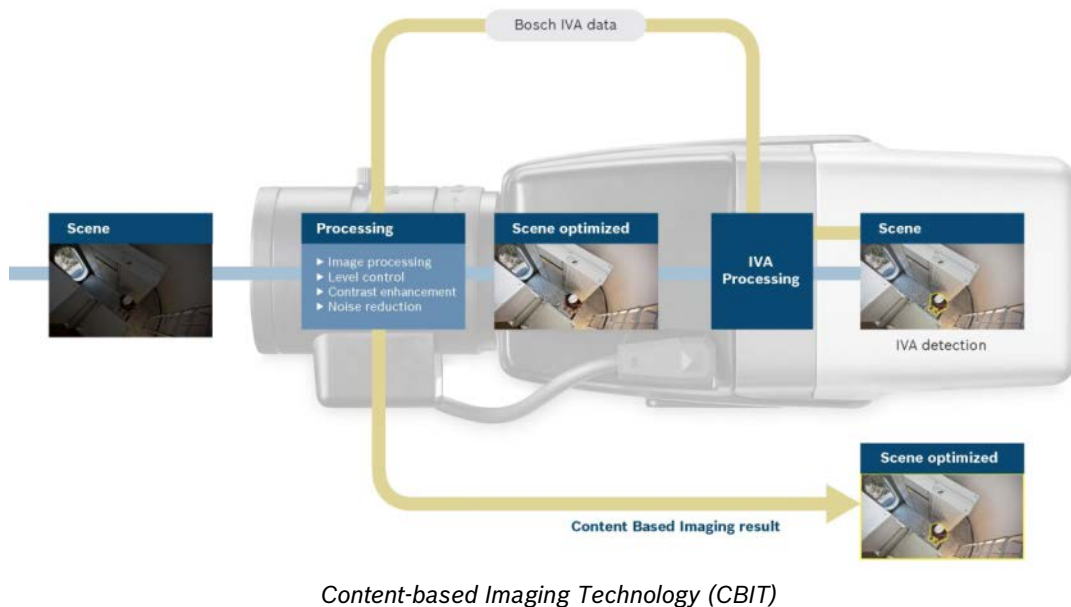
Intelligent Dynamic Noise Reduction (iDNR)

Classic noise reduction can take two forms. Spatial noise reduction averages the pixels within a frame to reduce noise. Temporal noise reduction involves averaging pixels over several frames to cancel out noise artifacts

Intelligent Dynamic Noise Reduction (iDNR) is a new approach that uses a combination of these two methods and dynamically adjusts them based upon light levels and the CBIT analysis of moving objects in the scene.

Comparison of images with visible noise (left), and reduced noise (right)

Temporal noise reduction is very effective for static images but can cause problems when there is motion in the image. If temporal noise reduction is applied to moving objects, ghosting may be visible in the image where objects are blurred or repeated. CBIT analysis identifies those frames in which there is movement and passes this information back to the DSP which then adapts the temporal noise reduction for these frames.

iDNR uses three factors to control spatial and temporal noise reduction:
- CBIT movement analysis
- Scene light level
- User-set levels

By combining these processes, iDNR optimizes bandwidth by dynamically tuning the degree of noise reduction based upon an analysis of important objects moving through the camera's field of view. When the scene is quiet or no motion is present, bandwidth is minimized. When an important object is detected, bandwidth increases to capture maximum details. iDNR's advanced algorithm can reduce bit rates and storage requirements by up to 50 percent in certain scenes without reducing video quality.

iDNR vs. VBR vs. CBR: what does it all mean?

Some Megapixel cameras by default restrict your bandwidth. Frequently, this is done via constant bit rate (CBR). CBR is an encoding method that keeps the bit rate at an arbitrary, fixed level. This can result in an always high bit rate, or when restricted to a low bit rate it can even result in an image quality that will never be at its best.
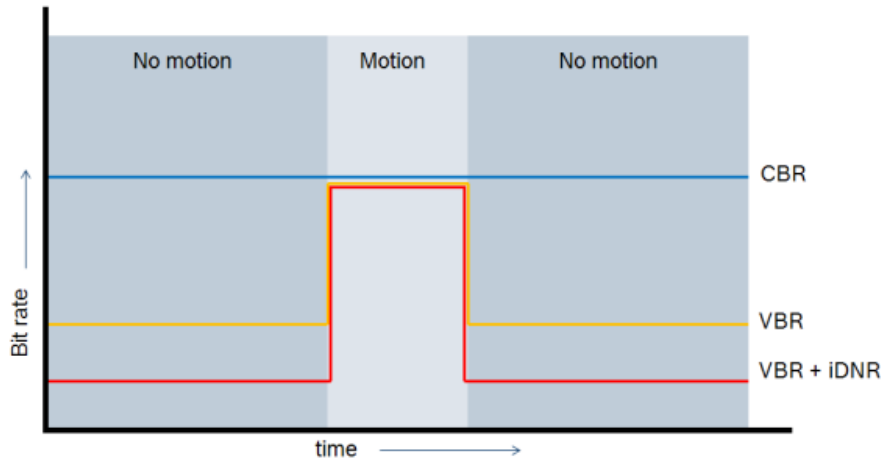
Graph demonstrating the relative bandwidth conservation of various noise reduction methods.

Variable bit rate (VBR), on the other hand, establishes a predefined level of image quality which can be maintained regardless of whether or not there is motion in a scene. Bandwidth will fluctuate depending on the scene.

iDNR operates on the same principle as VBR but with added intelligence to make smart decisions based on the presence or absence of motion in a scene. Basically stated, iDNR is a better, smarter form of VBR.

Region prioritization

In addition to iDNR, the region prioritization function allows for further bit rate reduction by adapting the encoder compression ratio for various regions of an image. Multiple regions in a scene can be defined, each of which is then assigned specific compression level parameters.

Area-based encoding allocates bandwidth to important parts of the scene.
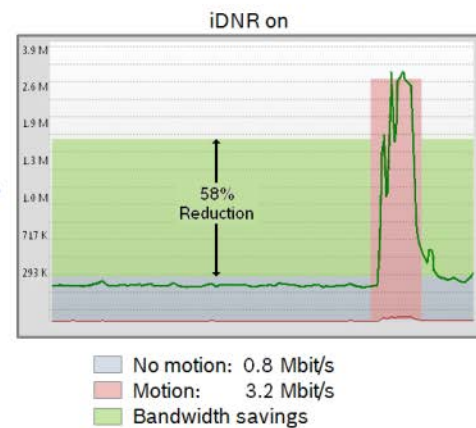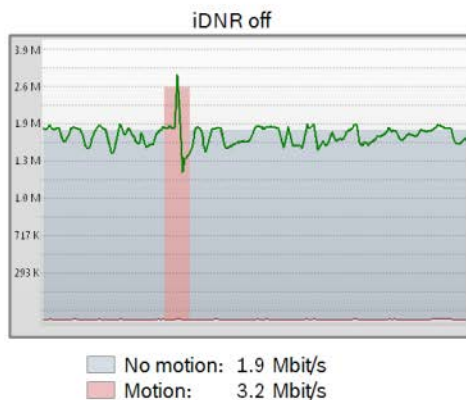
An unimportant region can be set to use more compression and thus reduce bit rate. Important regions can be assigned a lower compression ratio to show more details but this reduces the requirement for a constantly low compression ratio for the general picture. By thoughtful selection of important, unimportant and normal regions in a scene and adapting the compression ratios accordingly, a lower average bit rate can be achieved for a specific image.

Results

The effects of iDNR and region prioritization are additive, so you enjoy the cumulative benefit of both functions. This performance coupled with the high efficiency of the encoder compression algorithm produces measurable results. The following two examples summarize our test results:
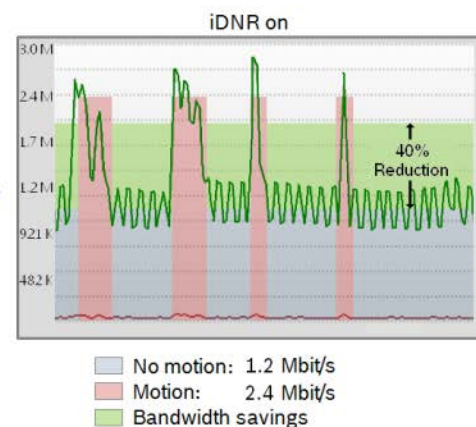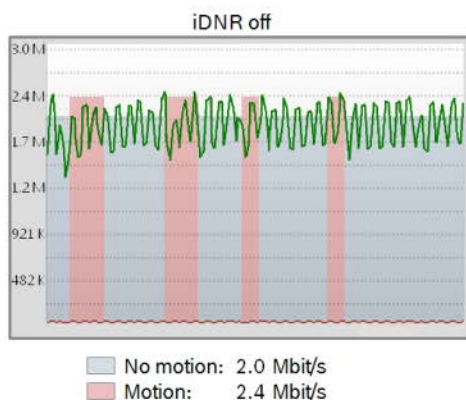
Indoor Scene

→ High level of detail due to texture brick wall
→ Severe movement
→ Bit rate reduction up to 58%

iDNR off

No motion: 1.9 Mbit/s
Motion: 3.2 Mbit/s

iDNR switched on

iDNR on

58% Reduction

No motion: 0.8 Mbit/s
Motion: 3.2 Mbit/s
Bandwidth savings

Outdoor Scene

→ Medium level of detail
→ Simple movement
→ Bit rate reduction up to 40%

iDNR off

No motion: 2.0 Mbit/s
Motion: 2.4 Mbit/s

iDNR switched on

iDNR on

40% Reduction

No motion: 1.2 Mbit/s
Motion: 2.4 Mbit/s
Bandwidth savings

*The graphs show bit rate spikes when motion is present in the image. When no motion is present, bandwidth decreases significantly. **Top**: a spike occurs when the two people walk through the hallway. **Bottom**: bit rate increases only when a cars drive through the scene.*

Turning iDNR into real savings

The savings that can be achieved with iDNR are easy to calculate. In our tests, bit rate reduction showed savings of up to 58 percent in one example. This can be directly correlated to savings realized in storage costs. So, in essence, if a video storage device costs $10,000 you may possibly only need to spend $4200 for the same amount of image detail being stored.

Scene	Complexity of scene	Bit rate reduction
	Laboratory scene (easy) Low level of detail and limited movement	48%
	Laboratory scene (details) High level of detail in fan and significant movement	33%
	Indoor scene (complex) High level of detail (brick wall) and significant movement	58%
	Outdoor scene Medium level of detail and significant movement	40%

Conclusion

Bosch has engineered the ability to tune the image pipeline based on scene content. As a result of this, we are able to implement Intelligent Dynamic Noise Reduction (iDNR) which can reduce noise in an image based on motion and light levels. iDNR generally delivers up to 50 percent bit rate reduction over standard VBR in scenes without motion. Combined with the full range of CBIT features, this means an overall reduction of up to 30 percent for your surveillance system – this means a dramatic reduction in required storage space, power and cooling which enables you protect your assets, your budget, and the environment.

Remember, it is always possible to reduce bit rate – but this normally affects image quality adversely. The key benefit of iDNR and region prioritization is that you get significantly lower bandwidth without loss of image quality.

Bosch cameras provide the most usable image possible by optimizing the detail-to-bandwidth ratio. This equates to considerable savings on storage costs without jepordizing image quality! Ultimately, the Megapixel camera that provides the highest quality video with the lowest bandwidth and storage requirements will be the most desirable choice for the customer.

Glossary

Constant Bit Rate (CBR)	Generates a steady bit rate that can be predefined. This is most often used when limited bandwidth is available. The disadvantage with CBR is that when added activity in a scene results in a bit rate that is higher than the target rate, the restriction to keep the bit rate constant leads to a lower image quality and frame rate.
Variable Bit Rate (VBR)	A predefined level of image quality which can be maintained regardless of having motion or no motion in a scene. Bandwidth will fluctuate depending on the scene: it will increase when there is a lot of activity, and decrease when there is no motion. This is often used in video surveillance applications where there is a need for high quality video with motion in a scene.

Product Spotlight

The technology discussed in this paper is featured in each of the following Bosch cameras.
Note: iDNR is based on smart motion detection (Motion+). Full IVA is not required.

Dome

FLEXIDOME IP 7000 RD/VR
►1080p, Day/Night

FLEXIDOME IP dynamic 7000 RD/VR
►1080p, High Dynamic Range

FLEXIDOME IP starlight 7000 RD/VR
►720p, Ultra light sensitivity

FLEXIDOME IP indoor 5000 HD
►1080p

FLEXIDOME IP indoor 5000 IR
►1080p, IR (50 ft)

FLEXIDOME IP outdoor 5000 HD
►1080p, IP66

FLEXIDOME IP outdoor 5000 IR
►1080p, IP66, IR (50 ft)

FLEXIDOME IP indoor 4000 HD
►720p

FLEXIDOME IP indoor 4000 IR
►720p, IP66, IR (50 ft)

FLEXIDOME IP outdoor 4000 HD
►720p

FLEXIDOME IP outdoor 4000 IR
►720p, IP66, IR (50 ft)

Fixed

DINION IP ultra 8000 MP
►12MP, High Dynamic Range

DINION IP starlight 8000 MP
►5MP, Ultra light sensitivity

DINION IP 7000 HD
►1080p, Day/Night

DINION IP dynamic 7000 HD
►1080p, High Dynamic Range

DINION IP starlight 7000 HD
►720p, Ultra light sensitivity

DINION IP 5000 HD
►1080p, Day/Night

DINION IP 4000 HD
►720p, Day/Night

Bullet

DINION IP bullet 5000 HD
►1080p, IP66, IR (82 ft)

DINION IP bullet 4000 HD
►720p, IP66, IR (82 ft)

Microdome

FLEXIDOME IP micro 5000 MP
►5MP, IP66 / IK8

FLEXIDOME IP micro 5000 HD
►1080p, IP66 / IK8

FLEXIDOME IP micro 2000 HD
►720p

FLEXIDOME IP micro 2000
►480p

Micro Box

TINYON IP 2000 HD
►720p

TINYON IP 2000
►480p

Specialty

FLEXIDOME IP corner 9000 MP
►1080p, IR (30ft), Vandal-resistant

DINION IP imager 9000 HD
►1080p, High Dynamic Range, IR (394ft)

EXTEGRA IP dynamic 9000 FX
►1080p, High dynamic range, ATEX

EXTEGRA IP starlight 9000 FX
►720p, Ultra light sensitivity, ATEX

PTZ

AUTODOME IP dynamic 7000 HD
►1080p, High Dynamic Range

AUTODOME IP starlight 7000 HD
►1080p, High Dynamic Range

MIC IP dynamic 7000 HD
►720p, Ultra light sensitivity

MIC IP starlight 7000 HD
►720p, Ultra light sensitivity