

White Paper

Low Light Level

Image Processing Technology

June 18th, 2020

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Noise occurred in the captured image can be classified into a Temporal Noise that noise changes over the time and a Fixed Pattern Noise that noise occurs in a fixed form. Temporal Noise occurs due to irregular motion generated from the heat of electrons inside the semiconductor, and the size is proportional to the absolute temperature. Fixed Pattern Noise occurs due to the spatial property variation generated between pixels close to each other.

In low light environments, if gain level is increased in order to raise sensitivity in low light environments, noise is amplified as much as signal is amplified. In extreme low light environment where the amount of light is insufficient, noise remains the same while the components of image signals decrease, resulting in greater noise effects. This noise degrades the image discrimination power and increases the size of the data when compressing image which causes reduction of transmission and storage efficiency.

Generating high quality images in low light conditions is a fundamental and essential element of video surveillance camera, and noise reduction technology is especially important for network based video surveillance camera in order to provide transmission and storage efficiency.

2. Key Elements of Low Light Performance **WISENET**

To generate high quality images in low light conditions, the following three elements are necessary.

First, it is key to design a lens capable of delivering as much light as possible from low light environments to the sensor, with minimum loss. This includes ensuring the lens has a small F-Stop number (large aperture opening), to provide the advantage of gathering more light to generate high quality images in low light conditions. Hanwha Techwin's own accumulated optical design technology made it possible to achieve the world's best F0.94 lens design technology for ultra-low light camera.

Second, it is necessary to have a high sensitivity sensor which reacts well, even in low light environments. The sensor industry has been introducing High Conversion Gain (HCG) technology and Backside Illumination (BSI) technology to improve sensor sensitivity. Furthermore, larger sensors, and larger pixels will result in better sensitivity. This is due to the fact that a sensor with a greater surface area per pixel has greater sensitivity, as more light is able to impinge each pixel.

Hanwha Techwin's extraLUX series, a family of WisenetX series, is featured with 1/1.9" sensor that has outstanding sensitivity and Signal to Noise Ratio (SNR) to provide excellent performance for low light environments.

Third, high complexity image processing technology is required. When generating an image in low light conditions, the sensor may increase the gain level to amplify the image signal. During this amplification, the noise contained within the image signal is also amplified. Noise in an image decreases the image quality and increases the image data size which in turn hinders transfer and storage efficiency.

Therefore, it is necessary to effectively eliminate noise using image processing technology.

There are many image processing methods designed to reduce noise, and they can be classified as 2-DNR (2-Dimensional Noise Reduction) and 3-DNR (3-dimensional Noise Reduction). 2-DNR is also known as "Spatial Noise Reduction" and it refers to the method that utilizes only the current frame to reduce noise present. On the other hand, 3-DNR, also known as "Spatio-temporal Noise Reduction," utilizes the current frame as well as the previous frame to reduce noise in the video. If no movement is detected from the comparison with the previous frame, it uses low pass filtering to reduce noise, and if movement is detected, it executes 2-DNR, which only uses the current frame. In general, 3-DNR noise reduction performs better than 2-DNR, but in case it fails to accurately detect movement, it can produce an afterimage, or motion blur.

Based on many years of experience in the image processing industry, Hanwha Techwin has developed a high performance noise reduction technology and an image correction technology which maintains brightness, color reproducibility and sharpness in extreme low light environments. These technologies are so called Smart Super Noise Reduction (SSNR) technology. Hanwha Techwin's SSNR is an advanced spatio-temporal noise reduction technology optimized for video surveillance cameras.

3. 1. Low Light Specialized Lens

Not like the lens used in general digital camera and camera camcorder, the lens used in cameras for video surveillance are typically taking IR corrected lens to match day/night focus and bright lens with low F value in consideration of the dark conditions.

WisenetX series is featured with Infra-red (IR) correction lens as a basic option, and WisenetX extraLUX series is featured with world's best level F.94 lens which is self-developed. In low light environment, lens with low F value has more advantages for image quality, but bright lens with low F value brings design difficulties as well.

One of the difficulties of optical lens design is, as the size of lens aperture increases, it gathers lights more correctly but the anastigmatic area increases as well. The other difficulty is the structural difficulty of managing alignment of the lens and sensor when the depth of focus becomes shallow.

Hanwha Techwin's accumulated optical design know-how enabled to overcome the difficulties by developing F 0.94 lens which the lens delivers more lights to the sensor in low light environments with less noise, offering color image surveillance in most night-time environments with wider range of image information.

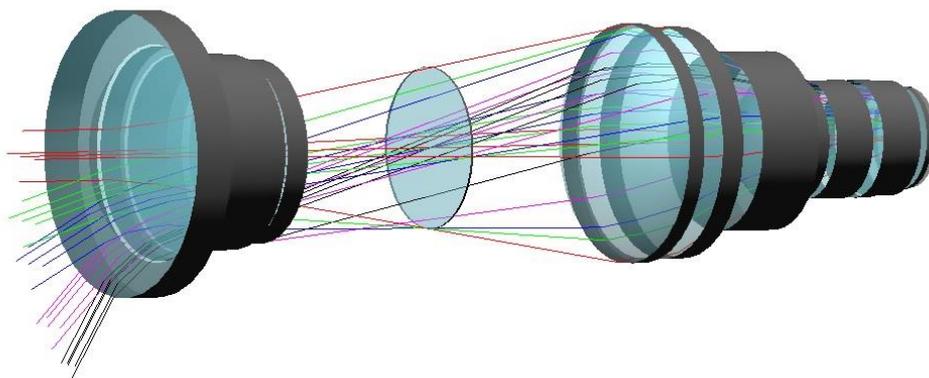


Image 1. E.g. Image of lens design for correction of various incident angles of light

3. 2. SSNR (Smart Super Noise Reduction)

The performance of SSNR (Smart Super Noise Reduction) applied to WisenetX series has been improved with the addition of AMD (Adaptive Motion Detection) and its own Pattern Matching technology optimized for dim-lit environment.

The AMD technology compares the incoming video input and previous frames to analyze any motion, and by calculating the probability of whether it is motion or not, 2-DNR, which is based on pattern matching, is applied to any area with motion detected in order to provide a clear image without any afterimages.

3-DNR is applied to areas without movement to not only remove noise but also to restore information lost due to noise and physical limitations. Through doing so, the image will contain accurate information which was not clear in the original frame. Furthermore, with Wise NR, the image is encoded with a low bit rate allowing the image to retain its clear image quality even when being transferred and stored efficiently.

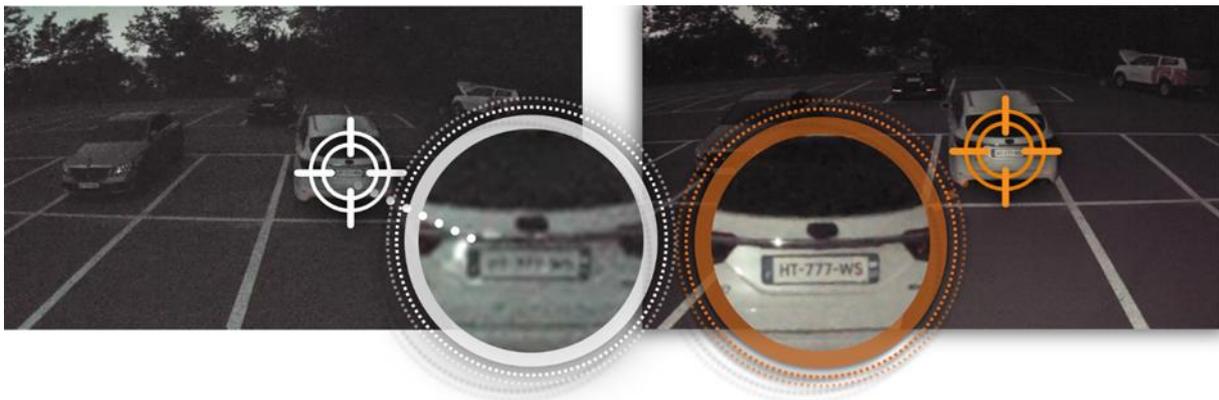


Image 2. Conventional (left) and Wisenet7 (right) Noise reduction technology comparison

3. 3. Low Light Image Enhancement Technology

Noise is greatly increased with respect to signal components as it goes into the extreme low light environments, and the critical nature of the applied sensor become clear, so that the reduction of dark discrimination power and the saturation occur as well as the data amount increase occur. Also, afterimage (motion blur) may get intensified when noise reduction is applied because of the small signal components and noise as a side effect.

Therefore, it is essential to have analysis of installation environments or scene changes, and obtain technologies for lens, sensor, noise reduction and Image Signal Processor (ISP) management in order to remove noise and maintain transmission performance, color reproducibility and image sharpness while securing visible sensitivity in extreme low light environments.

Hanwha Techwin has Exposure Control technology that optimizes noise in visible brightness range by calculating exposure value, ISP Control technology to ensure color reproducibility in low light environments, and technology that removes color noise occurred in signal processing.

Furthermore, Hanwha Techwin also has technology that corrects dark discrimination reduction caused by nonlinear response of the sensor by using Non-Linear Gain, technology that decreases bandwidth greatly in static scenes by using motion data, and technology that controls edge shapes (the intensity of the edge and the number of pixels occupied by the edge) to maintain the bandwidth.



Image 3. Nighttime Color Image Comparison between Previous Model (left) and WisenetX series (right)

3. 4. Noise Reduction Function Settings

Hanwha Techwin’s noise reduction function SSNR (Smart Super Noise Reduction) can customize the noise reduction level.

SSNR features three options: Off, On and Wise NR. It is recommended to use “On” in environments with lots of movement and “Wise NR” in environments with-medium low movement. The SSNR 2D level modifies spatial noise filtering level, and the SSNR 3D level modifies the temporal noise filtering level.

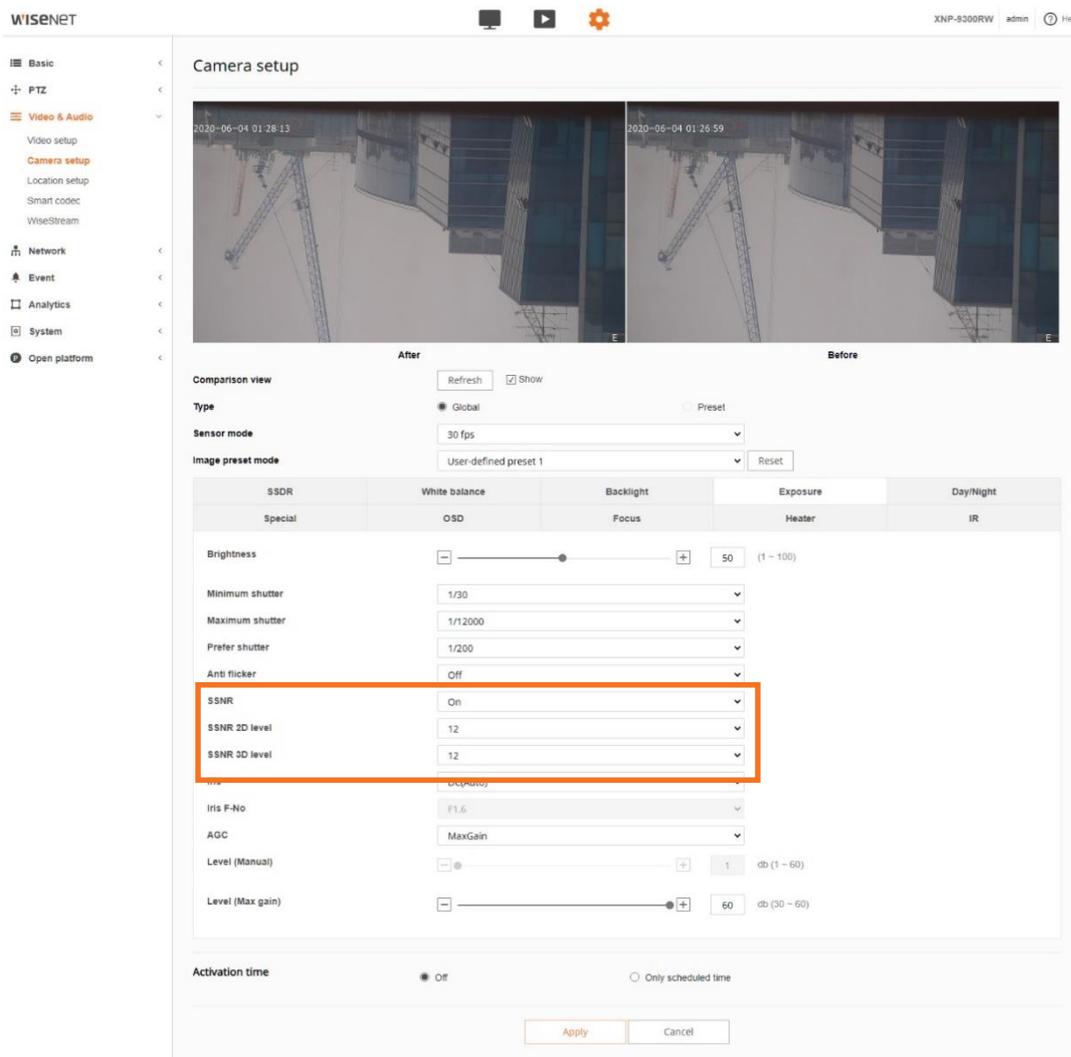


Image 4. SSNR Function Settings

- Menu Path : Camera Web Viewer → Setup → Audio & Video → Camera Setup → Exposure
- An excessively high 2D level can cause image quality degradation during noise reduction.
- An excessively high 3D level can produce an afterimage (motion blur) on moving objects.

4. Conclusion

Through SSNR which is the unique low light image process technology, Hanwha Techwin is able to provide clear color images in dark environments with limited light by effectively reducing noise, which is inevitable in low light level images, and by minimizing the afterimage (motion blur) of objects. Furthermore, with noise reduction applied, the image data size can be significantly reduced compared to images with high level noise in low light level conditions allowing efficient storage and network transmission.

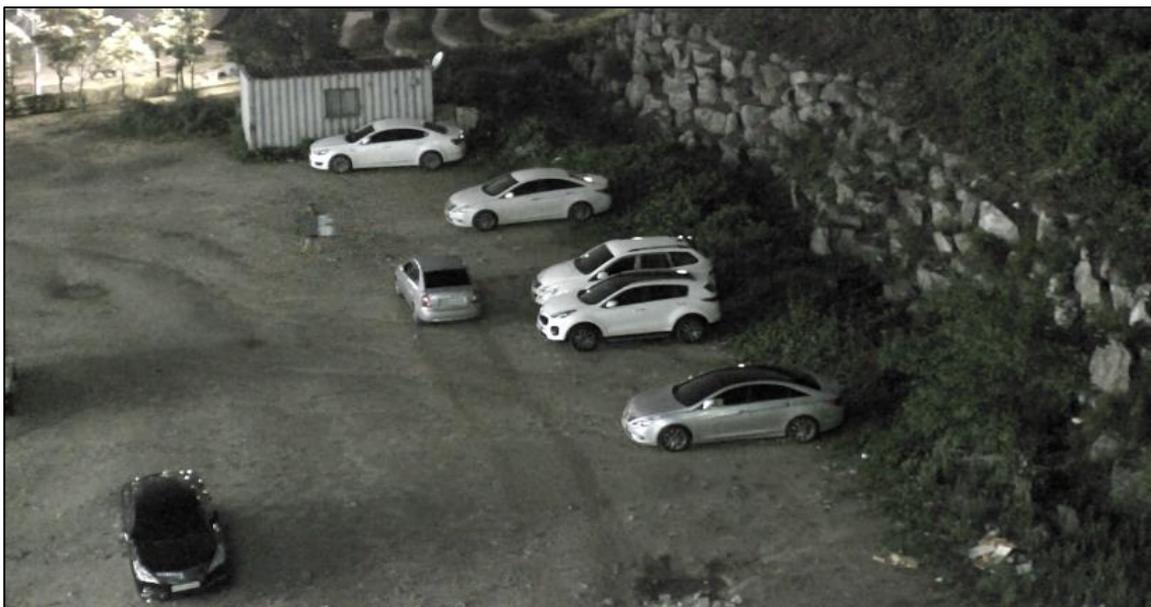


Image 5. Nighttime Color Image Comparison between Previous Model (top/1/2.8" 2M, F1.4) and WisenetX extraLUX series XNO-6085R (bottom/1/1.9" 2M, F 0.94)

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