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The Role of
ARTIFICIAL
INTELLIGENCE (AI)
To Transform Video Imaging

About the author

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The Role of Artificial Intelligence (AI) To Transform Video Imaging

By Larry Anderson

Artificial intelligence is changing the world of video security for the better, contributing to video capabilities such as better object recognition, more efficient search capabilities, and overall better real-time threat detection. In addition to these enhanced capabilities, AI is also helping to transform another aspect of video security; that is, the quality of the video images.

Today's AI, working with advanced chipsets and hardware advances inside video cameras, is overcoming the historic shortcomings of video cameras when it comes to image quality. Through the magic of AI, for example, video cameras today can provide precise color rendering and razor-sharp, clear images in ultra-low light.

This Technology Report, developed with the help of Hikvision, will describe the transformative impact of AI to recast video imaging for the better. Specifically, the report will focus on Hikvision's core technologies, ColorVu and Darkfighter 2.0, to demonstrate how advanced AI technologies are deployed to maximize performance, particularly in challenging lighting conditions.

Challenges of Low Light in Video Cameras

Low light conditions have historically presented multiple challenges for video cameras. Struggling to capture enough light and seeking to compensate, cameras boost the signal electronically and introduce unwanted "grain" or "noise" in the video. The slower shutter speeds needed to let in more light can make any movement of the camera or other objects create images that are blurry. Autofocus does not work as well in low light because there is little contrast and no obvious focal point. Color cannot be accurately reproduced in low light, and artificial lighting can cast a tint that obscures natural colors. Shadows and deep contrast caused by artificial lighting can lower dynamic range and obscure important details.

Specialized components called image signal processors (ISP) have helped to address several of the low-light challenges, including noise reduction, color correction, and white balance. However, image processors had not solved all the challenges, and the addition of artificial intelligence (AI) into the image processing equation enables cameras that take image quality to new heights.

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Max Fang,   Product Director - Hikvision

"AI significantly enhances video processing by improving clarity, contrast, and color, especially in low-light conditions," says Max Fang, Product Director at Hikvision. "AI image signal processing (AI-ISP) simulates human vision by performing tasks like auto-focusing, exposure control, and white balance adjustment in real time."

He adds: "The technology reduces noise and improves clarity and detail, making images resemble what we see with our eyes. Additionally, AI adjusts camera settings based on lighting and scene changes, thus ensuring consistent image quality."

To achieve these advancements, the process of training AI for video imaging involves several steps that ensure the AI can handle the complex dynamics of real-world environments:

- **Data collection** gathers diverse images and videos samples from various scenes;
- **Data preparation** organizes and labels the data accurately;
- **Model selection** involves choosing the right algorithm for the application;
- **Model training** uses the prepared data to teach the AI how to enhance image quality;
- **Testing and optimization** evaluate the model's performance and make necessary adjustments;
- **Model deployment** integrates the AI into real-world applications; and
- **Continuous improvement** refines the model using new data and feedback.

Hardware Components
Enable AI Signal Processing

Achieving AI-driven improvements in image quality requires several key hardware components inside the camera. The components enable high-capacity AI computations, particularly for enhancing image quality. These components include:
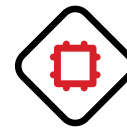
Image Sensor

Image Signal Processor (ISP)

AI-Enabled System on Chip (SoC)

Memory

Image Sensor

The cameras use larger, more sensitive CMOS (Complementary Metal-Oxide-Semiconductor) sensors. These sensors capture more light, thus improving image quality in low-light conditions and providing a solid foundation for AI processing.

Image Signal Processor (ISP)

The ISP processes raw data from the image sensor. It handles tasks like noise reduction, white balance, contrast adjustment, and color correction. With AI acceleration capabilities, the AI-ISP can run complex image processing algorithms faster and more efficiently.

AI-Enabled System on Chip (SoC)

The SoC supports deep learning algorithms, providing the computational power to run convolutional neural networks (CNNs) and other AI models. This enables real-time image recognition, classification, and enhancement, allowing the camera to perform advanced image processing tasks.

Memory

Upgraded high-speed, high-bandwidth, and high-capacity memory is essential for efficiently executing complex computations. This ensures that the processor can quickly handle large amounts of data, facilitating smoother and faster AI-driven image processing.

How AI Enhances Video Image Quality

Several artificial intelligence (AI) trends make the technology increasingly desirable for enhancing video image quality, says Fang. "Enhanced perceptual capabilities allow AI to adjust image parameters automatically, providing optimal image quality even in low-light conditions," he says. "The proliferation of high-performance processors has driven down the cost of powerful SoCs, enabling efficient high-quality image processing with low power consumption. Multimodal fusion integrates data from multiple sensors to create more accurate and comprehensive images, thus further improving image quality."

For instance, Hikvision's ColorVu technology leverages AI to provide color accuracy and high-quality, full-color video in low-light or nighttime conditions. Here is a breakdown of how Hikvision's ColorVu technology uses AI to significantly enhance video image quality and imaging processes:

> Hikvision's ColorVu technology leverages AI to provide color accuracy and high-quality, full-color video in low-light or nighttime conditions.

AI 3D LUT Color Correction	AI employs a full 3D color space to control image parameters such as color, brightness, and saturation. 3D refers to the inclusion of three separate color values – red, green and blue (R, G and B). Precise color calibration and detailed color mapping result in more accurate and vibrant images. LUT stands for Lookup Table. In color correction, a LUT is essentially a set of instructions that tells the software how to transform the colors in an image or video. The process assigns numerical values to the colors in an image and then transforms the original colors into new colors based on the instructions encoded in the LUT.
AI Noise Reduction	Leveraging vast amounts of data from low-light scenes, AI constructs intelligent noise reduction algorithms. These models effectively distinguish between useful signals and noise, filtering out noise to enhance the purity and visual quality of the image.
AI Motion Blur Reduction	Using smart algorithms within the SoC (System on Chip), AI provides higher resolution image and effectively addresses motion blur in low-light environments. This results in clearer and sharper images even when there is movement in dark conditions.
Enhanced Wide Dynamic Range (WDR)	AI combines multiple image exposures through intelligent algorithms to significantly boost the dynamic range. This ensures that bright areas are not overexposed, and details in dark areas are preserved, creating a balanced and natural-looking image.
Object Recognition	AI can enhance clarity of objects and recognition rates by applying specialized processing. It improves the clarity of important targets such as vehicles and license plates, making these elements more distinguishable.

Capturing Clear Detail with Sharper Motion in Low Light

Hikvision's DarkFighter technology performs well when the primary focus is on capturing clear and detailed video in low-light situations, even if it is in monochrome or grayscale. Notably, the technology enhances sharper motion, ensuring superior image clarity. Benefits of the Darkfighter 2.0 technology include:

SharpMotion

This technology is based on computational video noise analysis theory, using deep learning and neural networks to create a noise reduction model. By learning from large datasets, it can effectively separate signal from noise, removing unwanted noise and retaining more useful information. The intelligent algorithms of the main SoC chip enhance resolution, reducing motion blur in low-light environments. Additionally, it employs a full stereoscopic color space control method to adjust image color, brightness, and saturation, ensuring accurate color calibration and detailed color mapping.

ShotN	Through multi-frame exposure, this technology captures clear images of targets moving at different speeds in low-light conditions, such as pedestrians and vehicles at night. It addresses the common issue of standard cameras failing to capture clear images of moving targets at night.
Automatic WDR (Wide Dynamic Range)	Intelligent algorithms merge multiple image exposures to significantly enhance the dynamic range, ensuring that both bright and dark areas of the image are naturally blended. This prevents overexposure in bright areas and retains details in dark areas.
High Frame Rate	Darkfighter 2.0 supports up to 4K ultra-high-definition resolution at 60fps or 2MP resolution at 120fps, enabling the capture of fast-moving targets with exceptional clarity.
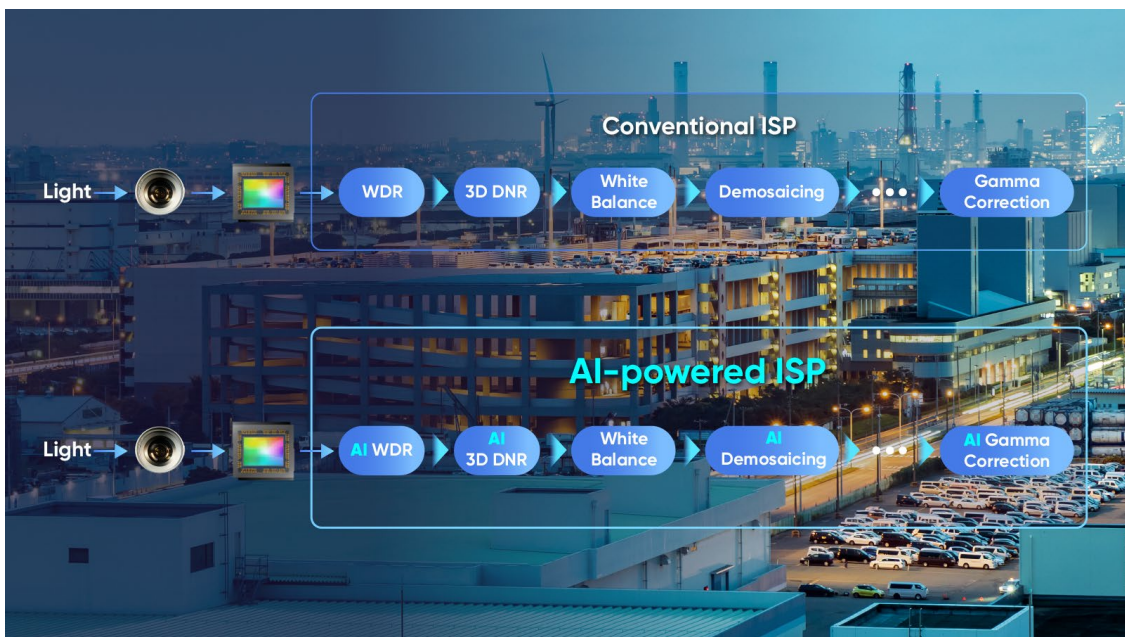
What's Ahead:
The Next Wave of Innovation

As we have seen, current AI technology has transformed the ability of video cameras to provide superior images even in low light environments. The next wave of AI technology is poised to bring even more significant advancements to video imaging, with several key developments on the horizon:

Real-Time High-Definition Enhancement

Using super-resolution technology, AI will be able to upscale low-resolution video to high-definition in real time. This will allow even cameras with lower resolutions or those capturing footage from long distances to provide clear, detailed images.

Multi-Camera Collaboration

AI will enable coordinated operation among multiple cameras, allowing for seamless tracking of moving objects across different viewpoints. This technology will ensure that no angle is missed, and AI will stitch together perspectives from various cameras to create comprehensive panoramic images, providing a more complete video security view.

Multi-Perception Fusion

AI will integrate data from multiple sensors, such as visible light, audio, X-rays, infrared, and radar, to perform multi-perception fusion processing. This approach will enhance overall image quality and perceptual effects, making video imaging more robust and informative.

Research and Development Drive the Next Evolution

Hikvision invests significantly in research and development, advancing its core technologies such as multi-dimensional perception, artificial intelligence, big data, and beyond. The company has leveraged imaging and video-related technologies to provide cutting edge innovations in low-light imaging, including the ColorVu and DarkFighter 2.0 technologies.

Imaging and video-related technologies remain important for Hikvision, and they have been leading the industry in numerous areas, including high definition and low-light imaging, as well as image defogging, smart rapid focus, and image stabilization, among others. Besides visible light imaging, Hikvision is also extending its machine perception technologies to the full electromagnetic spectrum. A range of tools driven by artificial intelligence (AI) is opening doors to new innovations. Addressing video imaging challenges is just the beginning.