Hanwha Vision

White Paper

AI Image Enhancements of Wisenet 9

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1. Introduction

In today's visually driven world, the demand for crystal-clear images and videos is paramount, yet achieving this in challenging conditions like low light or extreme backlighting remains a persistent hurdle. Conventional noise reduction (NR) methods often fall short, forcing a compromise between suppressing visual noise and preserving crucial image detail.

This white paper introduces Wisenet 9, Hanwha Vision’s latest SoC (System on a Chip), a groundbreaking innovation that fundamentally transforms how noise is managed in image processing. By integrating cutting-edge AI capabilities with conventional Image Signal Processing (ISP) techniques, Wisenet 9 delivers an unprecedented leap in image quality, offering enhanced visibility, remarkable clarity, and significant bitrate reduction. With this document, you can delve into the intricate details of Wisenet 9's architecture and its revolutionary approach to noise reduction, demonstrating how it sets a new benchmark for visual fidelity.

2. Wisenet 9's Core Technology for Image Processing

The Wisenet 9 SoC establishes a new benchmark for imaging performance. This is achieved through its fundamentally advanced core technology and a comprehensively refined suite of image processing capabilities, engineered to address complex visual challenges and deliver superior results.

2.1. Dual-NPU Architecture

The Wisenet 9 SoC distinguishes itself with a sophisticated internal architecture centered around two independent Neural Processing Units (NPUs). This dual-NPU design allows for specialized and optimized AI processing:

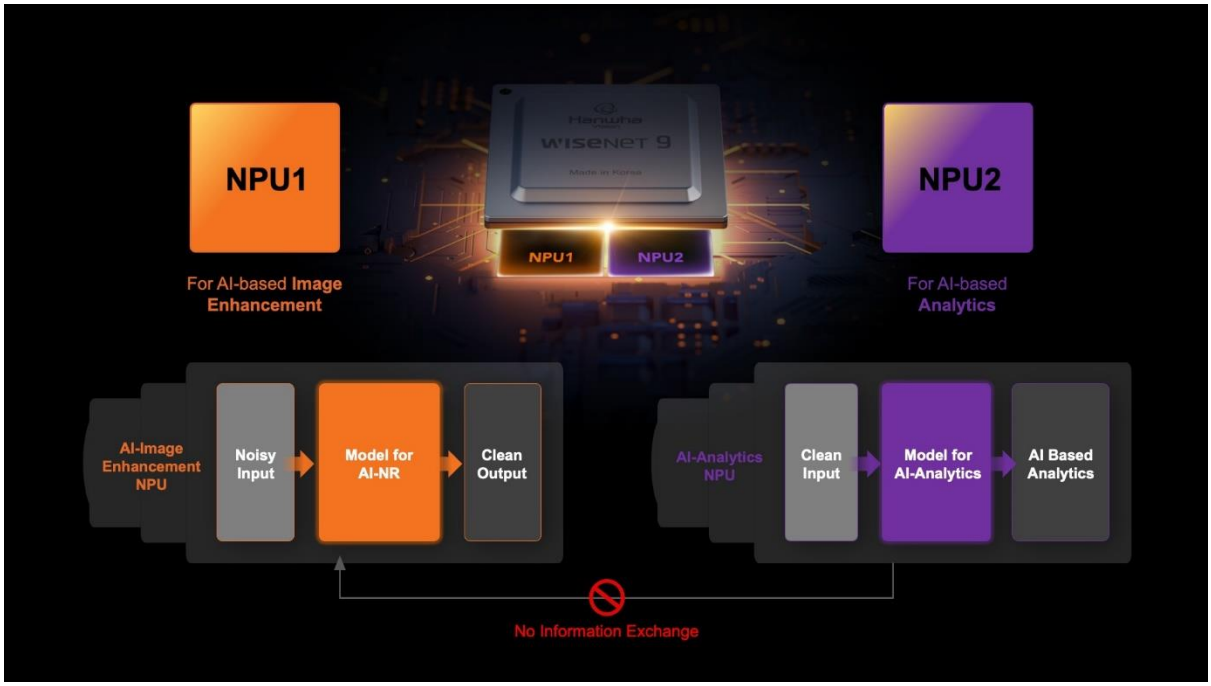

Figure 1.1: Wisenet 9's Dual-NPU Architecture

- **NPU 1 – AI Image Enhancements (including Noise Reduction)**

  This NPU is specifically engineered to handle AI-driven image improvements, with a primary focus on noise reduction. It employs a unique set of AI models meticulously trained to identify and mitigate noise artifacts.

  Unlike conventional methods that rely on general assumptions about noise, Wisenet 9's AI noise reduction is trained to recognize the specific noise characteristics of each individual sensor. This sensor-specific training allows the system to accurately distinguish noise from genuine image data, leading to highly precise and effective noise removal. The mechanism is similar to conventional noise reduction in its goal of replacing noisy pixels with cleaner data from neighbors or previous frames, but the crucial difference lies in the AI's ability to determine what constitutes "noise precisely."

- **NPU 2 – AI Analytics**

  Complementing the image enhancement NPU, the second NPU is dedicated to advanced AI analytics tasks. This includes functionalities such as object detection, re-identification (Re-ID), and attribute extraction. The cleaner, denoised image input provided by NPU1 significantly enhances the robustness and accuracy of these AI analytical tasks, particularly enabling more reliable object detection in challenging low light conditions compared to analysis performed on conventionally processed images.

The independent operation of these NPUs ensures that image enhancement processes, including noise reduction, do not interfere with or consume resources from the analytical tasks, and vice versa. While operating independently without direct information exchange, the design enables a holistic and efficient processing pipeline.

2.2. AI Noise Reduction

Wisenet 9 fundamentally redefines the traditional approach to noise reduction by **integrating a sophisticated AI-based Noise Reduction (AI-NR) directly into the existing Noise Reduction pipeline within the ISP**. This innovative hybrid architecture enhances and optimizes the conventional NR techniques, yielding a significant and comprehensive improvement in image quality across various challenging scenarios:

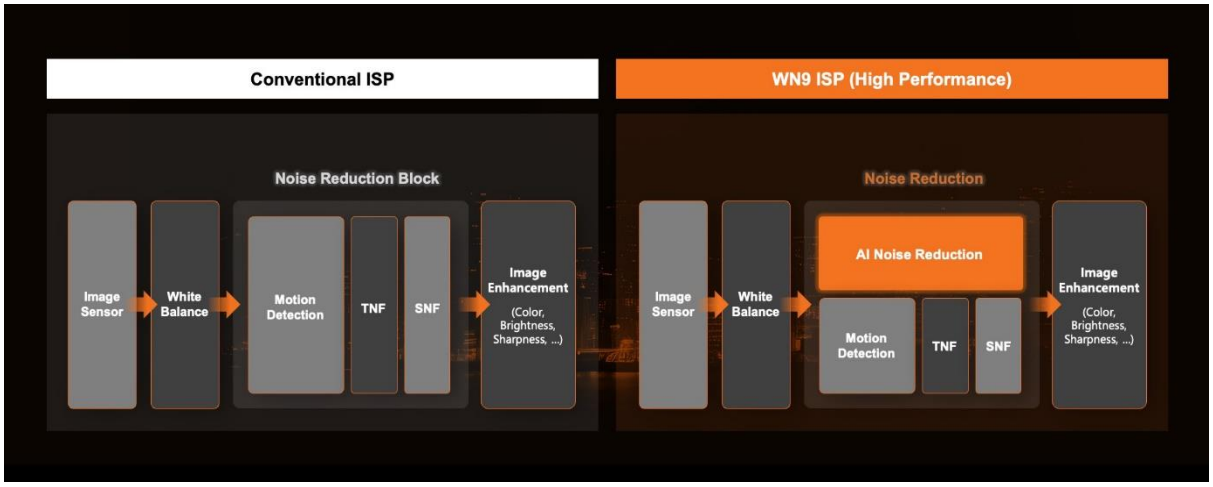

Figure 1.2: Comparison of Conventional ISP and WN9 ISP Architectures

- **Beyond Conventional Limitations**

  Traditional ISPs, while offering foundational NR capabilities, often encounter inherent limitations. When applying subsequent image enhancements such as

color saturation or sharpness, any residual noise can be inadvertently amplified. This phenomenon compromises overall image quality and restricts the expressive potential of imagery, particularly under demanding conditions like low light or extreme backlighting.

Wisenet 9 directly addresses these limitations by leveraging AI to dramatically elevate overall NR performance. This substantial reduction in noise, achieved through the synergistic operation of AI-NR and conventional filtering techniques, provides unparalleled freedom in applying strong image enhancements. Users can now create truly superior image quality with vibrant colors and sharp details, free from the typical drawbacks of noise amplification.

- **Superior Bitrate Reduction**

  A compelling advantage of Wisenet 9's advanced noise reduction is its profound positive impact on bitrate efficiency. By precisely and effectively minimizing noise—which is essentially random, redundant data—the system generates inherently cleaner images. These cleaner images require significantly less data to encode, leading to a superior bitrate reduction when compared to other camera solutions. This translates into substantial benefits for storage capacity, network transmission bandwidth, and overall operational efficiency.

2.3. Image Processing Workflows

The intelligent image processing workflow within Wisenet 9 is a key differentiator, enabling an unprecedented level of precision in noise management. **This workflow is underpinned by the synergistic operation of both conventional and AI-driven techniques, followed by selective per-pixel noise reduction.**

Wisenet 9 uniquely integrates established noise reduction methodologies with its advanced AI-driven capabilities to achieve exceptional synergy, where the AI-NR acts as the core intelligence. Conventional-NR creates clean images through temporal/spatial filtering, adapting its approach depending on whether there is movement or not, and this traditional method effectively addresses general noise patterns. Complementing this, **AI-NR is specifically trained for each sensor to identify and reduce gain-specific noise characteristics**, offering a far more granular and adaptive approach to noise mitigation.

The power of AI-NR lies in its highly specific training. Since AI-NR undergoes the process of training on noise that varies for each sensor and its specific gain settings, it is possible for the system to **precisely determine whether each individual pixel is a noise pixel or a clean pixel**. This granular decision-making is a direct result of its learned understanding of sensor-specific and gain-specific noise characteristics, allowing for unparalleled accuracy at the pixel level.

This intelligent per-pixel discrimination forms the basis of Wisenet 9's highly selective and effective noise reduction process. In the case of a pixel identified as “clean,” the AI-NR leaves its value untouched, maintaining its original integrity and detail. Conversely, when a pixel is classified as a “noise pixel,” it is replaced with clean data derived from its neighboring pixels or temporal information, based on the AI model's learned insights. This precise, non-destructive approach to clean pixels and targeted modification of noisy pixels is fundamental to **preventing "hallucination" in the object unit**, a common and undesirable issue where less advanced denoising might introduce artificial patterns or distortions. The result from Wisenet 9 is a highly accurate and artifact-free denoised output that faithfully preserves the natural appearance of objects within the scene, setting a new standard for visual clarity.

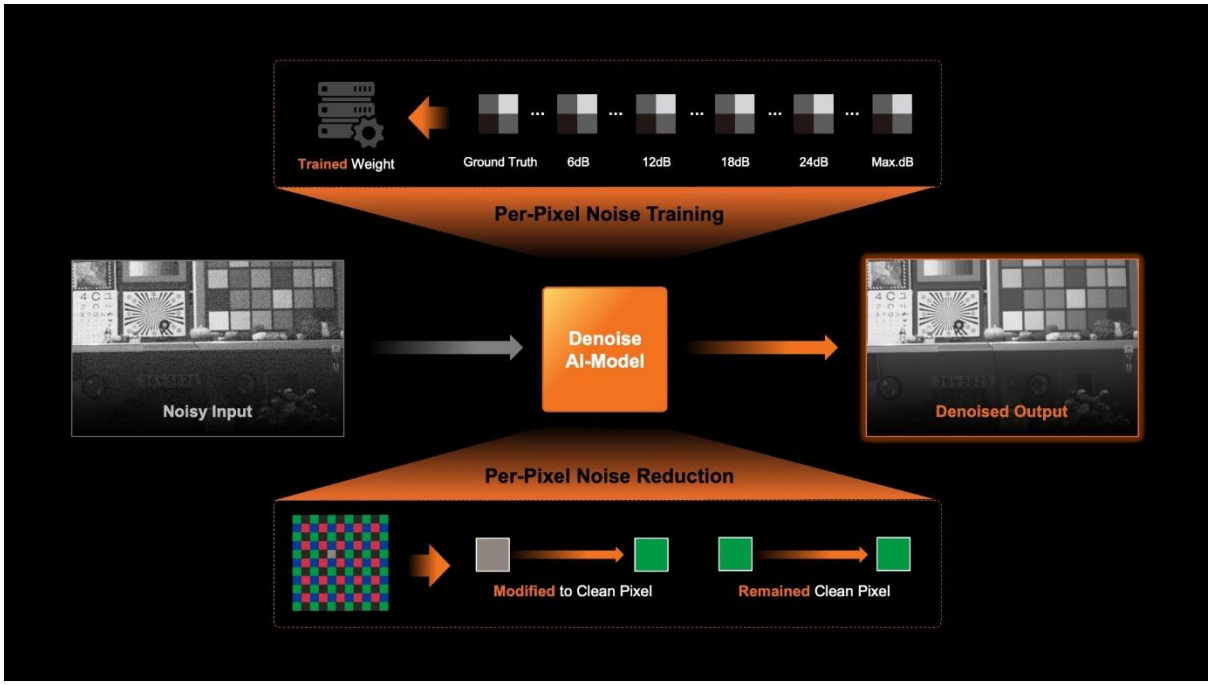

Figure 1.3: Per-Pixel Noise Training and Reduction Workflow

2.4. Benefits

The overarching image processing workflow in Wisenet 9 is designed to overcome the inherent challenges of image processing, particularly when dealing with digital gain amplification. Images captured directly from the sensor are inherently very dark. They undergo a crucial brightening step through digital gain within the ISP to produce a visible image. A critical problem arises if noise persists in the image even after initial denoising. When digital gain is applied, this remaining noise is severely boosted, resulting in a significantly noisy output that degrades image quality. This noisy video not only impairs visibility for viewers but also dramatically increases the bitrate, consuming bandwidth and storage.

Wisenet 9 directly addresses this challenge by implementing a powerful combination of AI-NR and conventional-NR to significantly reduce noise before the digital gain stage. This comprehensive and proactive noise mitigation is paramount to achieving superior results. By effectively suppressing noise at its source, Wisenet 9 allows for the subsequent application of various image processing techniques, such as color and sharpness enhancements, and dynamic range optimization, to truly maximize visibility without introducing unwanted artifacts. As demonstrated in Figure 1.4, this proactive approach transforms the outcome from extremely low light conditions, enabling "Strong Image Enhancement" where conventional methods would struggle.

The result is truly transformative. Even when strong image enhancements are applied to create exceptionally bright and vivid images, the final output from Wisenet 9 contains very little residual noise. This low noise content directly translates into an extremely low bitrate, achieving a harmonious balance between stunning visual quality and remarkable data efficiency. This unique capability makes Wisenet 9 an ideal solution for applications where both image clarity and optimized data management are critical.

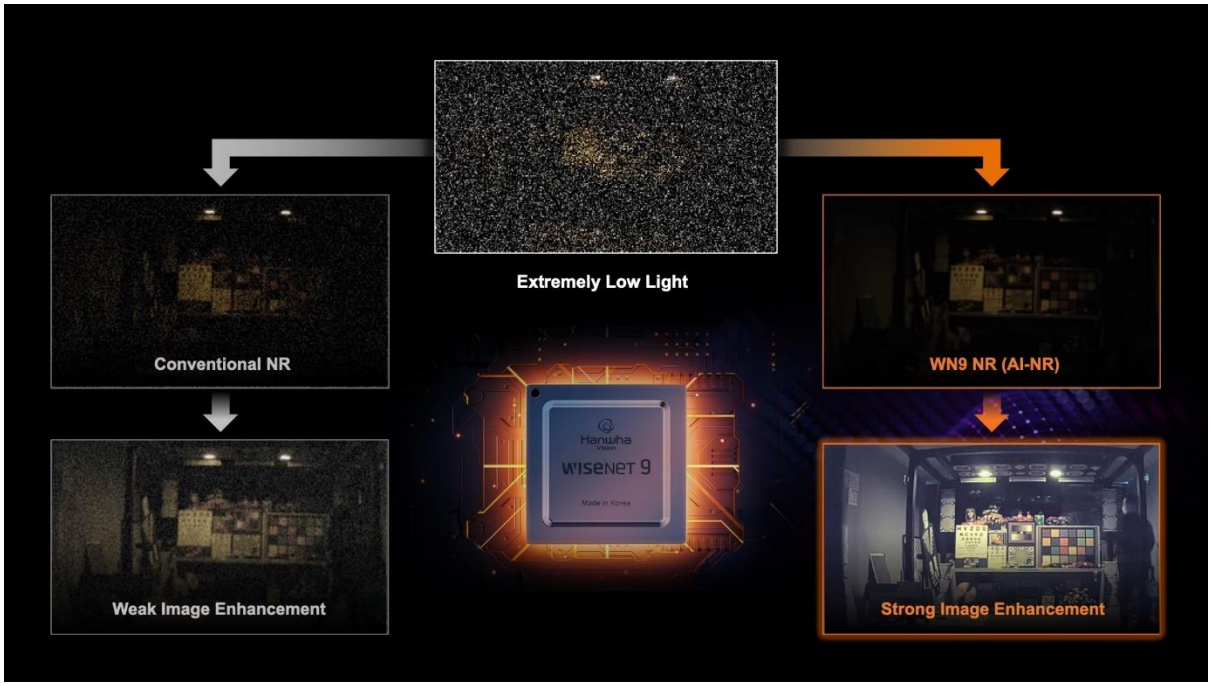

Figure 1.4: Comparative Visual Impact of Noise Reduction and Image Enhancement in Low Light

3. Conclusion

Hanwha Vision Wisenet 9 represents a monumental advancement in the field of image processing, particularly in the ever-critical domain of noise reduction. By pioneering a unique dual-NPU architecture and implementing a synergistic hybrid AI and conventional noise reduction approach, Wisenet 9 delivers an unparalleled level of image quality, especially under the most challenging low light and extreme backlight conditions. The AI's sophisticated, pixel-level precision in identifying and mitigating sensor-specific noise characteristics ensures images are not only clean and vivid but also remarkably accurate, completely eliminating problematic artifacts like hallucination.

Beyond visual fidelity, Wisenet 9's ability to drastically reduce noise translates into a superior bitrate performance, offering substantial and tangible benefits for data storage, transmission, and overall system scalability. This is not merely an incremental improvement over existing technologies; it is a fundamental rethinking of noise management that sets a new industry standard. Wisenet 9 empowers users with clearer vision, more reliable data, and significantly more efficient operations, making it an indispensable solution for the video surveillance industry.

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